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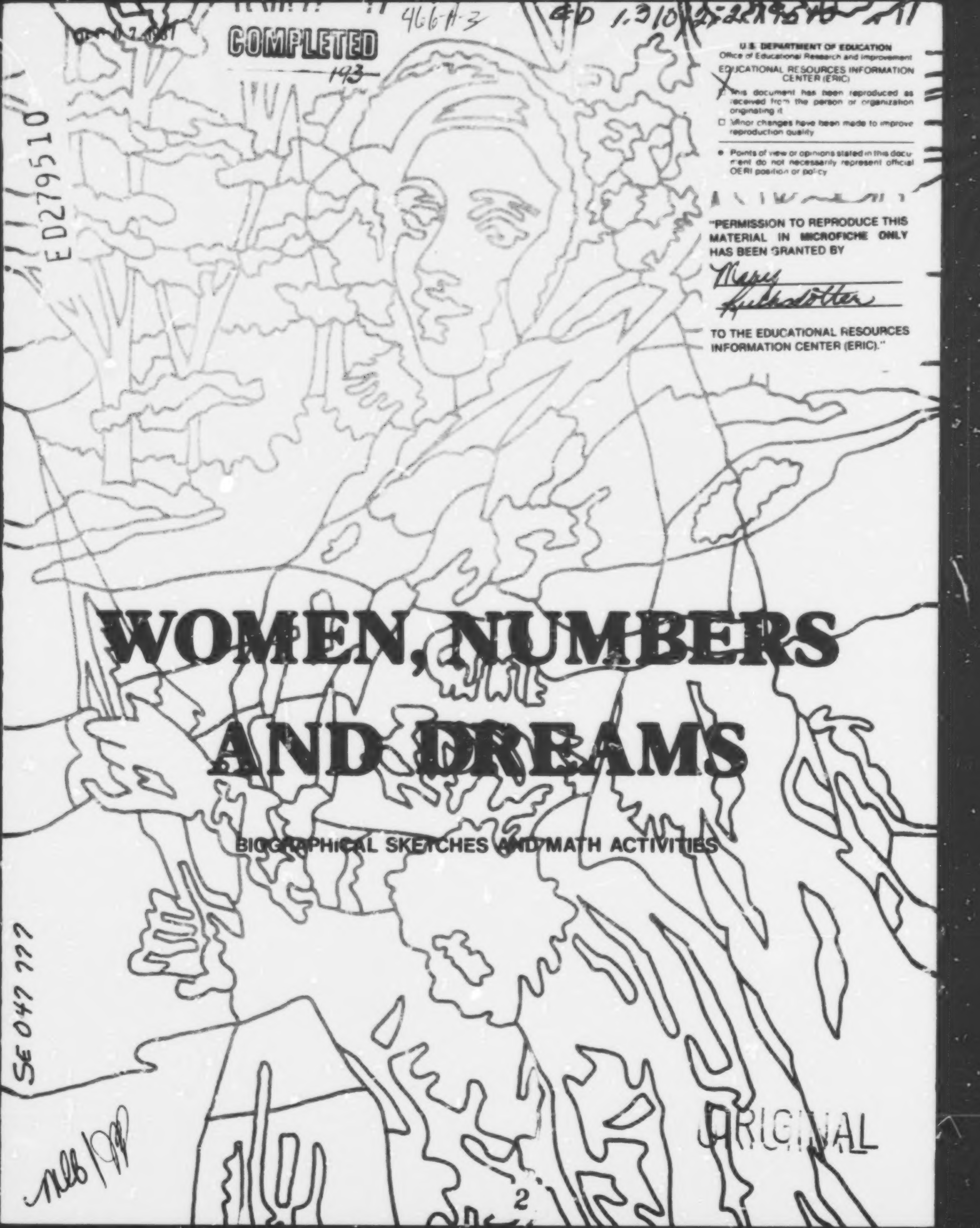

WOMEN, NUMBERS AND DREAMS

BIOGRAPHICAL SKETCHES AND MATH ACTIVITIES

ORIGINAL

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ABSTRACT

This booklet was written to provide role models for young people. Included are stories of 13 interesting women who have worked in careers that require substantial training in mathematics, with the hope of encouraging students to aspire to careers in fields using mathematics. Both contemporary and noncontemporary women are included to provide contrast between situations faced by women today and in the past. Mathematics activities are included to show that mathematics is far more than the arithmetic learned in elementary schools. Elementary number theory concepts such as prime numbers, triangular numbers, and common multiples are reinforced in mathematics shade-ins, where a picture is tied to the story. Role play is also incorporated. Biographical stories are given for Mary Somerville, Ada Lovelace, Sonya Kovalevskaya, Mary Boole, Emmy Noether, Lenore Blum, Evelyn Boyd Granville, Fanya Montalvo, Edna Paisano, Grace Yang, and three computer consultants from Wisconsin. (MNS)

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WOMEN, NUMBERS AND DREAMS

BIOGRAPHICAL SKETCHES AND MATH ACTIVITIES

Teri Hoch Perl Joan M. Manning

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The reader is permitted and encouraged to make photocopies of the math activities.

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Women, Numbers and Dreams

Preface

This is the last quarter of the twentieth century, and most women expect to work the greater part of their adult lives. We want to share the stories of a group of women whose work has been very important to them. Some of these women lived long before you were born. Like you, they are from different backgrounds.

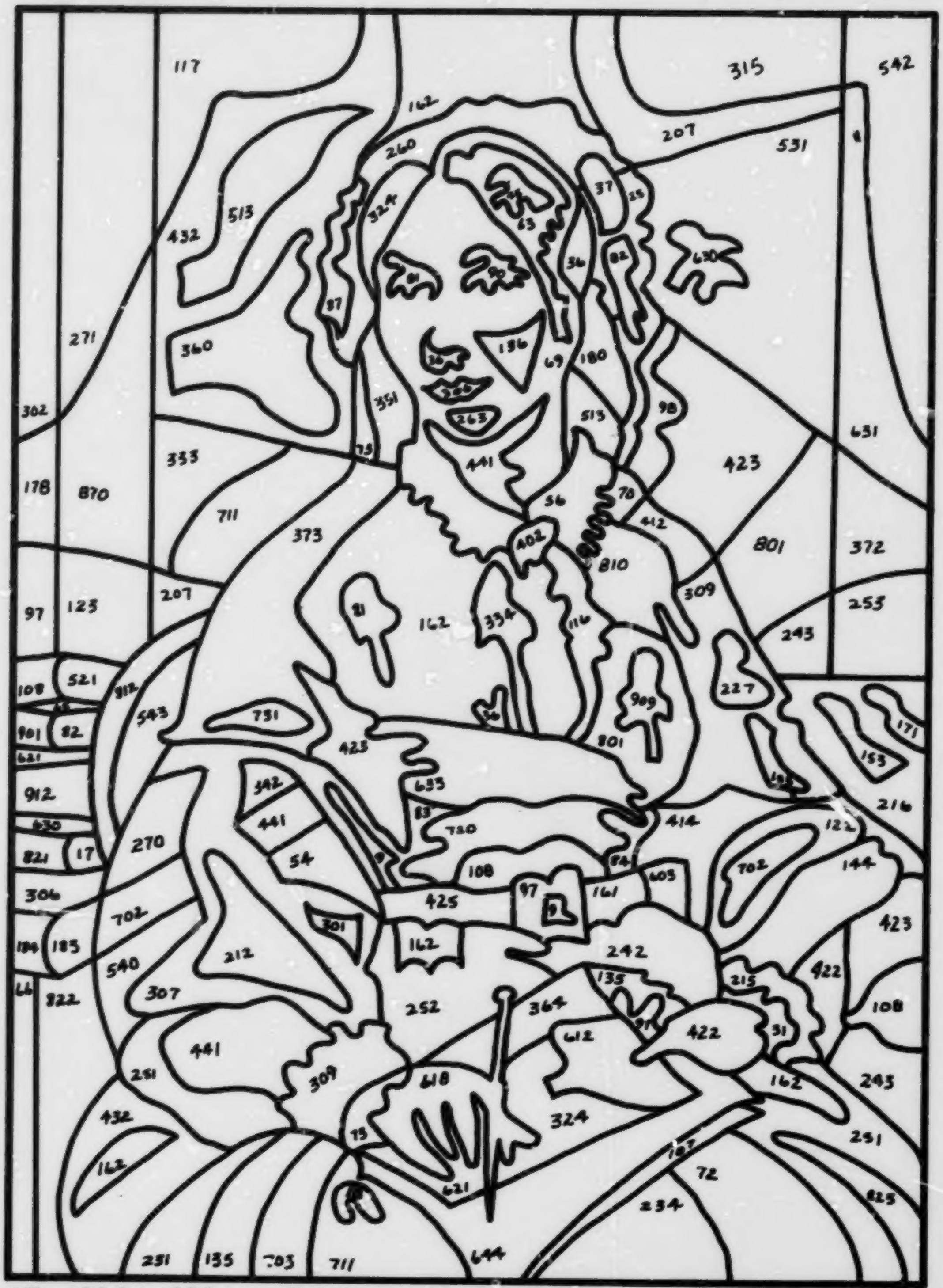
To all of them, their work has been rewarding in many ways. They work on interesting problems. They are proud of the results of their work. Among the contemporary women, good salaries allow them independence. These women are the lucky ones.

In the last chapter, you will read about a conference to inspire young women to join these lucky ones. It is a true story, as are all the other stories in this book.

Young women growing up now can become whatever their talents and dreams allow. Become one of the lucky ones. Dream big and keep your options wide open.

MARY SOMERVILLE

SHADE ALL MULTIPLES OF 9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All multiples of 9 have a digital sum of 9. See page 95 for details on how to find the digital sum of any number.

MARY SOMERVILLE

1780-1872

Mary Somerville was born in Burntisland, a small village on the northern seacoast of Scotland. As a child she loved to roam out-of-doors. She had only to step through an opening at the end of her garden and she was on the shore.

"When the tide was out," she wrote, "I spent hours on the sands, looking at the star-fish and sea-urchins, or watching the children digging for sand-eels, cockels, and the spouting razorfish. . . I knew the eggs of many birds, and made a collection of them. I never robbed a nest, but bought strings of eggs, which were sold by boys. . . I also watched the crabs, live shells, jellyfish, and various marine animals, all of which were objects of curiosity and amusement to me in my lonely life."

Mary's father was an Admiral in the English Navy. When Mary was about ten years old he came home after a long voyage. He noticed how wild Mary had become from her constant outdoor explorations and insisted she be sent off to a boarding school. Mary spent one year at Miss Primrose's boarding school.

Miss Primrose's School

Away from the wild Scottish coast, Mary was desperately unhappy. She was befriended by some older girls who flushed her eyes with water in order to hide the tears that were almost constantly running down her face.

At school she learned reading, writing, French and English grammar. The method of teaching was mostly memorizing: for instance, Mary had to memorize an entire page of Samuel Johnson's famous dictionary, giving the spelling, pronunciation and definition of each word in order. Poor Mary! She had no memory for subjects which did not interest her.

Add to this the costume she had to wear during her lessons: a steel busk or framework fitted around her chest under her gown. Another steel piece attached to this busk fitted over her shoulders, drawing them back so far her shoulder blades touched in back. A third metal piece fitted in a semicircle under her chin. In this suit of armor she had to learn her lessons, as did all the younger girls in the school. This was supposed to keep them from slouching!

Mary never did adjust to life at the school, and at the year's end she returned home still writing and spelling poorly. She wrote to her older brother who was at school at Edinburgh and asked him to buy her something with the "bank-knot" she sent.

Later, when Mary was thirteen, she lived for a winter in Edinburgh which was a nearby large city. There she went to a day school to study writing and arithmetic. Finally she learned to write "a fair hand" and found that she liked arithmetic.

Home Life

Learning something new always interested her. But before she could follow the studies she grew to love she had some hard times at home. Whenever she gave her opinion on a subject she was "instantly silenced, although (she wrote) I often knew, and could have proved, that I was in the right." Mary was timid and hesitated to speak up. These shy feelings never left her though they were much less strong when she was old and famous.

Her relatives disapproved of her when she was a teenager because she read so much. Her father said, "We must put a stop to this, or we shall have Mary in a strait jacket one of these days. There was X., (another girl) who went raving mad about the longitude!"

It was commonly believed that girls and women could go mad if they exercised their minds too much. It was also believed, even by doctors, that too much study would affect the ability of women to bear children.

That was one area, though, in which Mary was "determined and inflexible"--the pursuit of her studies. Bit by bit she learned French, Latin and Greek. The subjects that fascinated her most were the ones that grew out of her love of nature. She had always had a keen eye for observing fish, birds, plants and the night sky.

Using a small globe that showed the constellations, Mary studied the skies from north- and south-facing windows in her attic bedroom. Later, from reading a book on navigation, she learned that astronomy was not just star-gazing, and that to make progress she would need to know higher mathematics to chart the constellations.

Puzzles and Clues

One day a friend of Mary's showed her a needlework pattern in a "ladies magazine." As the friend leafed through the pages, Mary's eyes were drawn to a number puzzle, but included with the numbers were the letters x and y.

Mary said to her friend, "What do these letters mean?"

Her friend replied, "Oh, it is a kind of arithmetic. They call it Algebra, but I can tell you nothing about it."

Her friend had no information but Mary had at least the name of the mysterious subject--algebra. Later, when she was taking lessons in landscape painting (painting and needlework were considered acceptable subjects for girls to study), she heard her teacher talking to some of her classmates. He said, "You should study Euclid's *Elements of Geometry*, the foundation not only of perspective, but of astronomy and all mechanical science."

Another clue! Now she knew what books to ask for--books on algebra and geometry. About that time a tutor was hired for Mary's younger brother. This kind person agreed to buy the books Mary so desperately wanted and he did it on his very next trip to Edinburgh.

"Now," said Mary, "I had got what I had so long and earnestly desired.

"Before I began to read algebra I found it necessary to study arithmetic again, having forgotten much of it. I never was expert at addition, for, in summing up a long column of pounds, shillings, and pence in the family account book, it seldom came out twice the same way."

Reading Euclid's work on geometry was consigned to the nighttime, after the rest of the family and servants went to bed. The servants discovered that the candle supply was practically used up by Mary's nightly reading habit. Mary's mother told them to take away all her candles at bedtime.

Mary wrote, "I had, however, already gone through the first six books of Euclid, and now I was thrown on my memory which I exercised by beginning at the first book and demonstrating in my mind a certain number of problems every night, till I could nearly go through the whole."

Accomplishments

Studying mathematics was not the only thing Mary did. She spent hours every day at household chores and made and mended all her clothes, even her ball gowns.

About this time Mary and her mother went to Edinburgh to spend the winters. Here Mary paid many social calls and went to dances, where everybody danced reels and other country dances. Young ladies were somewhat free at that time in Edinburgh and it was the custom for gentlemen to carry them to dances in sedan chairs. Mary was permitted to be transported by gentlemen her mother knew. Mary loved dancing and was never without partners. She often came home from a dance in bright daylight.

Mary had a small and delicate face and figure and wore becoming and fashionable gowns. She was very fresh looking and was called "The Rose of Jedburgh," Jedburgh being the name of the town where Mary stayed with relatives.

As always Mary loved to read, so much so that one day Mary's aunt, who lived with the family, said to her mother, "I wonder you let Mary waste her time in reading. She never sews more than if she were a man."

Mary disagreed. She wrote, "I was annoyed that my turn for reading was so much disapproved of, and thought it unjust that women should have been given a desire for knowledge if it were wrong to acquire it."

Mary loved music too and practiced the piano hours each day. However, when her family obliged her to perform in front of company, her shyness returned and she played badly. Mary hated to do poorly.

As a landscape painter she was accomplished and her work was passed around to friends of the family who encouraged her. Though Mary did not seriously consider a career as a painter she was, she wrote, "intensely ambitious to excel in something, for I felt in my own breast that women were capable of taking a higher place in creation than that assigned to them in my early days, which was very low."

Marriage

When Mary was twenty-four she married. Her husband was a distant cousin of hers named Samuel Greig and he was Consul to Russia. Before consenting to the marriage, Mary's father insisted upon knowing that Mary would never have to live in Russia. There, stormy politics made life for foreigners dangerous, for in this year, 1804, Napoleon had declared himself Emperor and was leading his troops to battle with the Austrians and Russians.

Mary, who had grown up in a small Scottish village on the northern seacoast, moved with her husband to London where the Russian consulate was located.

Her husband did not forbid Mary to study but he had no good words for her occupation. Like most other people, he thought that educating women and girls was foolish and useless.

During the next three years, two sons were born to the couple. Then, suddenly, Samuel Greig died. In those days illness often carried off people very suddenly. There were no drugs or innoculations against diseases such as cholera, pneumonia or influenza.

Widowhood

Mary moved with her babies back to her parents' house. At twenty-seven she was a widow. There was one thing she could do--throw herself into her beloved studies.

For the first time in her life she did not have to meet with anyone's approval, for she was now independent. She resumed her old schedule of early morning and late evening study. She devoted the days to her children.

A Career

At this time there were "ladies magazines" that contained sewing and needlework patterns and recipes just as the "Ladies Home Journal" and "Woman's Day" do today. "The Ladies' Diary," for instance, was a magazine that was published for well over 100 years in England during Mary's lifetime.

Magazines and journals then had one major difference. They contained problems and puzzles in mathematics. Mathematics was something new to ordinary people who were not educated, and women were interested in the subject equally with men. It was not thought that mathematics was "over the head" of women.

Mary began to work on problems given in one such journal. She sent her solutions to the editor, Mr. Wallace. He was impressed with them and he sent back his own solutions.

"Mine were sometimes right and sometimes wrong," she wrote, "and it occasionally happened that we solved the same problem by different methods."

Finally Mary solved a problem in algebra and won a prize. It was a silver medal with her name on it. She was very pleased.

This same Mr. Wallace became Professor of Mathematics at the University of Edinburgh. Mary told him she wanted to learn "the highest branches of mathematical and astronomical science" and he gave her a list of books which were written in French, Latin, and English. The list included books on algebra, physics, calculus, geometry, astronomy, logorithms and probability theory.

"I was thirty-three years of age when I bought this excellent little library," she said of herself. "I could hardly believe that I possessed such a treasure when I looked back on the day that I first saw the mysterious word 'Algebra', and the long course of years in which I had persevered almost without hope. It taught me never to despair."

A Proposal

Mary received several offers of marriage. One offer, sent in writing as was the custom, listed the duties of a wife in such a narrow-minded way that Mary tossed it right away. She was no longer a child and she knew what she wanted.

After a time a cousin named William Somerville proposed marriage and Mary gladly accepted. He and Mary were married for sixty years and they were very happy together.

William, whom Mary always called "Somerville" in her writings, was very proud of Mary's growing skill as a mathematician. He searched out books at libraries for her. Since he was very interested in the correct use of language, he re-copied her manuscripts before they were sent to the printer in order to correct any errors in spelling, punctuation and grammar. He was not jealous of her fame or her mental brilliance. He was, Mary wrote many years later, one in ten thousand.

The First Book

Lord Henry Brougham, a publisher, realized that an English translation was needed of a new and important work on astronomy, written in French. He asked Mary to do the work. Because she had never studied at a university and had taught herself, she doubted her own ability.

She told her husband and Lord Brougham, "You must be aware that the work in question never can be popularized, since the student must at least know something of the differential and integral calculi, and as a preliminary step I should have to prove various problems in physical mechanics and astronomy. Besides, La Place (the author) never gives diagrams or figures, because they are not necessary to persons versed in the Calculus, but they would be indispensable in a work such as you wish me to write. I am afraid I am incapable of such a task, but as you both wish it so much, I shall do my very best upon condition of secrecy, and that if I fail the manuscript shall be put into the fire."

She did not fail and her first book, *The Mechanism of the Heavens*, was published in 1831. In the work Mary published her own solutions to difficult problems set by La Place. She gave clear accounts of experiments and gave examples. She wrote an introduction which was suitable for the ordinary reader.

The book was an instant success. It was used as a textbook for students at Cambridge University which was the center for the study of mathematics in England.

Professor Peacock, a mathematician from Cambridge, wrote to Mary, "I consider it to be a work of the greatest value and importance . . . which will contribute greatly to . . . the knowledge of physical astronomy."

After this she published three more books: *The Connection of the Physical Sciences*, *Physical Geography* and *Molecular and Microscopic Science*. Mary had discovered her niche--spreading knowledge about her beloved subjects. Her books were used by mathematicians, scientists and students. They sold well and were important in popularizing science.

This was a time when science was becoming a great influence upon the lives of ordinary people and many people were excited and curious about it.

Fame

Mary received many honors, honorary degrees, and medals. A statue of her was placed in the Hall of the Royal Society in London. In 1834, The Royal Astronomical Society named her and Caroline Herschel as its first honorary female members. A new sailing ship was called the "Mary Somerville" and a copy of her statue was placed on the ship's prow as a figurehead.

Because Mary was a woman working in a field where almost no women were to be found, she was especially famous. Since she successfully combined marriage, family, femininity and a scientific career, she helped the cause of other women interested in mathematics and science. She accomplished this at a time when women were not even admitted to universities.

As she grew older she continued to be very energetic. She packed every day with activity. As long as she lived she rose early, studied until early afternoon, then put her books away. From then on she took care of her household and went out to visit friends. Of course she, like everyone of her social class, had servants to make this schedule possible.

Family Life

She and William became interested in minerals. They invested their money in gems such as rubies, sapphires, topaz and amethysts. In the evenings they liked to take their collection out of the cabinet and arrange the gems or just admire them.

Mary had three daughters. The oldest, a child of unusual talent, died and Mary grieved for a long time. The two surviving daughters, Mary and Martha, never married but stayed in their parents' household.

In the 1840's when Mary was in her sixties the family moved to Italy. William was ill and the doctors advised a warmer climate. Woronzow Greig, Mary's son by her first marriage, continued to live in England with his own family. Mary and Woronzow were very close; they often visited and wrote letters back and forth. Woronzow handled Mary's legal and publishing affairs.

As her career progressed, Mary turned from mathematics to science. She later regretted this decision since she believed her greatest gifts were in mathematics.

A Pet

All her life Mary loved birds, especially songbirds. A mountain sparrow was her pet for eight years and when Mary sat in bed in the morning, writing and reading, the bird would fly in and perch on her arm.

She had a horror of killing animals, either by hunting or by vivisection--even for scientific experiment. After she grew up she petitioned the lawmakers of England and Italy to outlaw these practices, which she believed were cruel. When Mary was a very old woman she wrote that she believed that God, in his great mercy, would provide an everlasting home for the helpless animals, as well as for human souls.

Old Age

Mary Somerville lived to be 92 years of age. By that time few of her friends remained alive.

"I am nearly left alone," she wrote. Indeed, her beloved husband and son had died before her.

Her daughter Martha published her memoirs a couple of years after her death. Martha wrote that Mary worked up to the very day she died. She was quite deaf but her eyes were good until the end--so good that she could pick out the threads of her needlework canvas without using glasses.

Mary's great happiness was that she never lost the power of her mind nor her memory. Even in her nineties, she could work difficult problems in algebra with the same joy and determination she knew as a young girl.

MULTIPLES OF 3 AND 5

Numbers that are common multiples of 3 and 5 are numbers that are multiples of 3, and at the same time are multiples of 5.

The last digit of all numbers that are multiples of 5 is either five or zero. Any number that ends in anything but five or zero fails that test.

All numbers that are multiples of 3 leave no remainder when divided by 3, and have a digital sum that is 3 or 6 or 9. The digital sum test is easy to do.

See page 95 for details.

All numbers that pass both tests are common multiples of 3 and 5.

Shade these common multiples and you will see Mary on her way to the Ball.

Mary's System

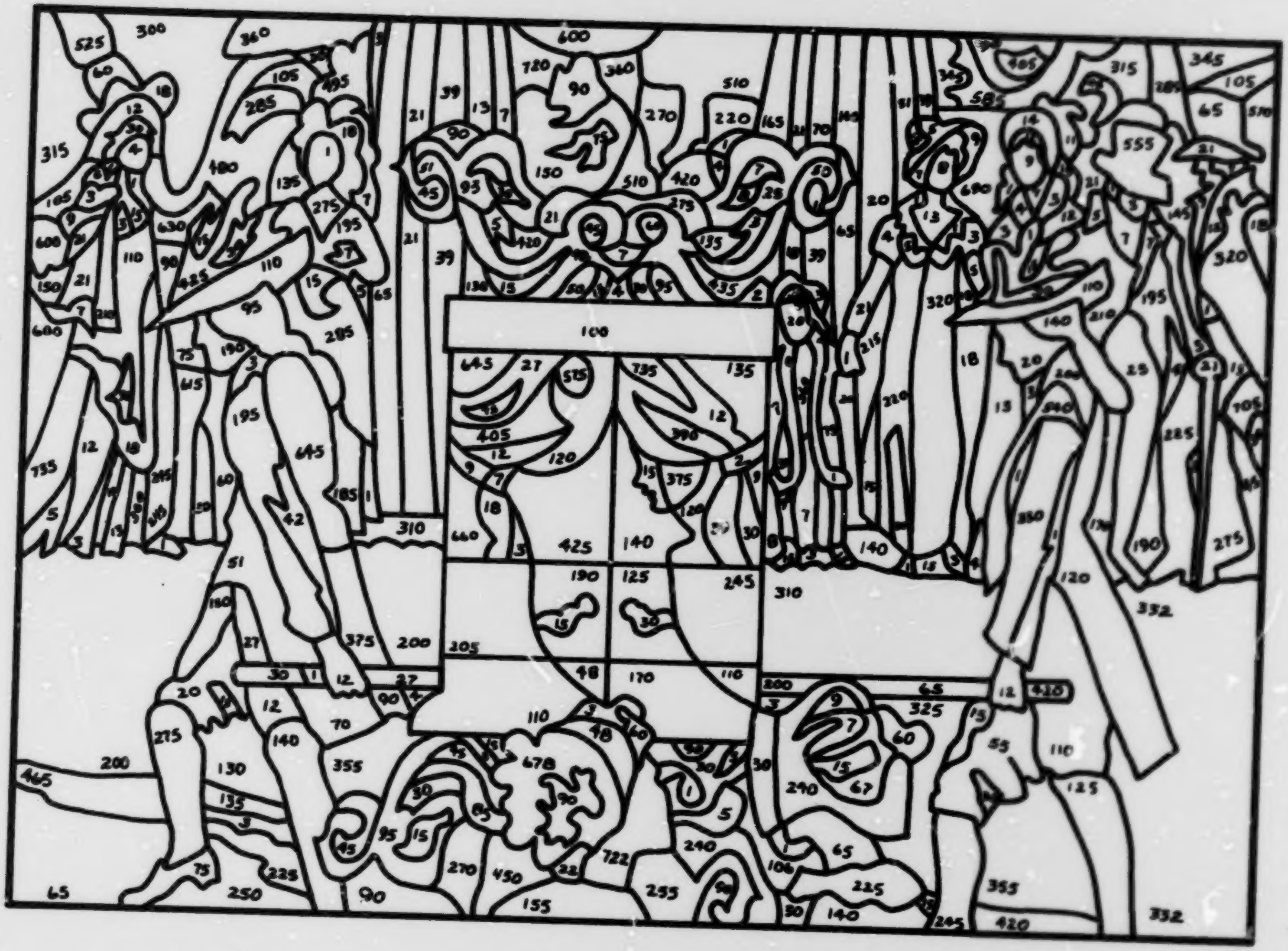
Mary Somerville used a system in her work that would be useful today. If she couldn't find the key to unlock a difficult problem she stopped working and turned instead to the piano, her needlework, or a walk out-of-doors. Afterward, she returned to the problem with her mind refreshed and could find the solution.

If she could not understand a passage in her reading, she would read on for several pages. Then, going back, she could often understand what was meant in the part which before had been confusing.

When she was trying to master geometry she worked out problems mentally at night in bed, beginning with the simplest problems and proceeding to more complex ones.

Her success as a mathematician may have depended in part upon these basic habits.

'ON THE WAY TO THE BALL'--SHADE ALL COMMON MULTIPLES OF 3 AND 5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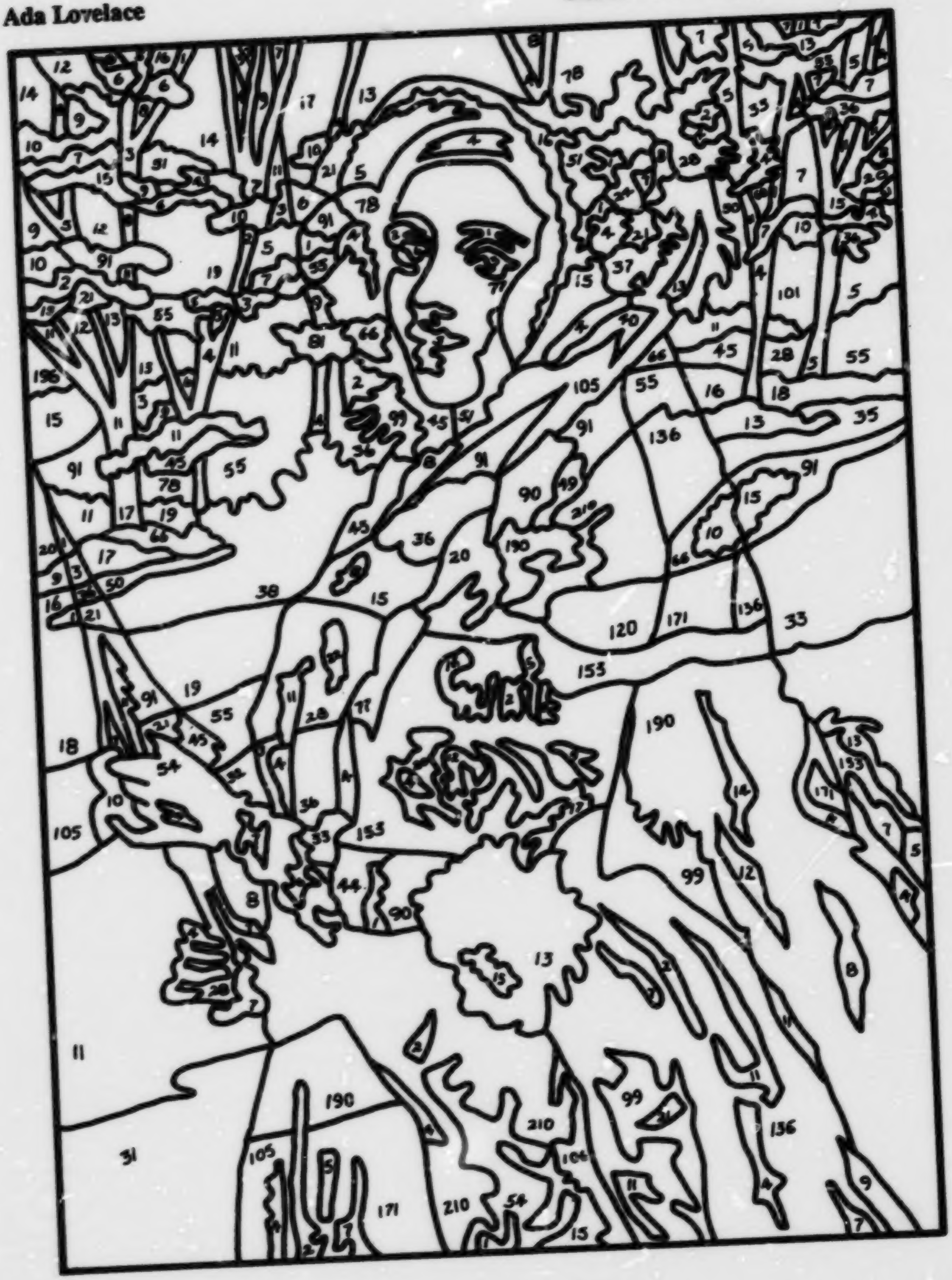
Shade all Triangular Numbers

Ada Lovelace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ADA LOVELACE
1815-1852

Pussy cat, pussy cat, where have you been?
I've been to London to look at the queen.
Pussy cat, pussy cat, what did you there?
I frightened a little mouse under her chair . . .

Whether timid as a little mouse or courageous as a lion, only Ada, in her 17-year-old heart knew, for she had learned to keep the feelings in her heart secret. Her mother called her "the young Lioness" when she was presented to the queen in the London season of 1833.

Ada was on the brink of entering the grown-up world, for she was meeting King William IV and Queen Adelaide at the Court of St. James. Her full name was Augusta Ada Byron, and she was thrilled with the splendor of the company and of the Palace itself. She had attended few parties in the past but in the winter of 1833, she went to many balls and dinners. This was her "coming out" season.

At these gatherings, for the first time in her life, she met many important and famous people. Many of them were not only famous, but they were intelligent, accomplished and witty. Ada yearned to be part of their group.

Lord Byron, Her Father

In a way you could say that Ada had been born into such a group. Her father, George Gordon, Lord Byron, was a poet who was known and loved throughout the world.

Lord Byron had come to London when he was a young man. He became known in society quickly because of his poetry, which made fun of the great literature and writers of his day. He was also talked about in social gatherings because he was a handsome man, and because he had affairs with many rich and beautiful women.

Besides being a playboy, Byron wrote biting criticisms of the weaknesses of English society. He attacked corrupt politicians and their lies. He stood up for factory workers when they rioted because of terrible working conditions.

Byron flirted, threw away his money, traveled all over the Continent and had many adventures. Finally, one day, home from his travels and attending still another party, he met an attractive, very proper young English woman named Annabella Millbanke.

This young woman had been brought up in a comfortable upperclass English country home. She believed in values such as duty, obedience and good works. She was a gifted student of mathematics and literature and she had read Byron's poems.

Unlikely as it seems, these two people fell in love. They married, but they did not "settle down." They moved about from place to place. Lord Byron treated Annabella very cruelly at times and made it clear that he was sorry he had married her. She, in turn, prayed for his soul, and pointed out his problems in long-winded speeches.

One year was all the marriage lasted. A week after the birth of their daughter, Ada, husband and wife separated forever.

Lady Annabella went to her parents' home with Ada; Lord Byron stormed away to Italy.

Ada! sole daughter of my house and heart?
When last I saw thy young blue eyes they smiled
. . . when we parted,--not as now we part
But with a hope . . .

Byron wrote this poem about Ada when she was one year old. It expressed his longing to see her but his wish was never fulfilled. Byron died in Greece, fighting in a war for Greek freedom from the Turks.

"The Separation," as everyone in English society called it, was gossipped about for many years. Lady Byron kept most of the gossip from reaching Ada's ears as Ada grew up. But though everything was "hush-hush," the young girl felt something. When the news of her father's death reached the family, when Ada was eight years old, she cried.

Ada was caught between the two extreme types of her parents' personalities. This conflict took its toll. Although as a child she had been described as cheerful and robust, she suffered a kind of nervous attack when she was eight years old--perhaps migraine--which is brought on by stress. Again, in her mid-teens, an attack had frightening consequences. Her legs became paralyzed, and it was nearly a year before she could move about normally.

Ambition

Ada overcame these illnesses and actually went on to became active in gymnastics, dancing and her great love--horseback riding. Her letters show her to be a high-spirited person despite being constantly surrounded by her mother's advisors, who were all given to preaching at the teenage girl about almost everything.

Ada had outstanding mental gifts. She loved music and was a promising and versatile musician: she played harp, violin and piano. She enjoyed mathematics and loved mechanical things. When she was eight and nine years old, she constructed and played with toy ships and boats.

Her mathematical interests persisted. When she was seventeen and studying algebra and astronomy, which she had mostly taught herself, she wrote playfully to a friend, "So this you see is commencement of 'A Sentimental Mathematical Correspondence between two Young Ladies of Rank' to be hereinafter published no doubt for the edification of womankind . . . Ever Yours Mathematically."

During her "coming out" season in London, Ada was looking for others to share her great love for mathematics, music, and riding, and anything else that was interesting and new. Most of all, she wished to meet the famous Mrs. Somerville. Mary Somerville was at this time living in London. She had just published *The Mechanism of the Heavens* on mathematical astronomy. This book was being read with fascination by the educated people of the day. Ada dreamed of becoming a famous mathematician like Mrs. Somerville.

Babbage and the Difference Engine

One of the brightest stars of the London scene was Charles Babbage, an inventor who had studied at Cambridge University. Babbage traveled widely and involved himself in many scientific projects. He loved to see and be seen at the best parties and balls. At one of these, Ada was introduced to him. She was delighted. He invited Ada along with her mother to see his pet project, an early computer.

This computer project, in fact, obsessed him. He called it the Difference Engine and it had many moving parts. This machine would be able to produce, with awesome speed and accuracy, tables for astronomers and navigators to use. Up to this point, these tables could only be computed tediously by people who multiplied and divided huge amounts of numbers. Their accuracy, of course, was limited. The Difference Engine added numbers instead of multiplying them, and the most powerful thing about the machine was that it could add heaps of numbers extremely quickly and accurately. The tables which were computed by the Difference Engine were badly needed, because shipping was England's leading industry. So Babbage received two grants of money from the government to build his machine.

Although Babbage was a genius, he was not a very good manager. When the money ran out the workmen whose skills he needed to produce all the Engine's precision parts quit for lack of wages. The project was never completed.

When Ada saw the Difference Engine she was enthralled. The evening after Babbage's demonstration to her and her mother, Ada went to the Queen's Ball and again conversed with Babbage. Thus began a professional tie and a friendship which lasted throughout her life.

Ada wanted to work with Babbage and began studying differential equations so that, as she wrote to him, "at some future time . . . my head may be made by you subservient to some of your purposes and plans." But it was to be some time before she would begin working with Babbage.

Meanwhile, Ada wrote about her work to another well-known mathematician, Augustus DeMorgan. DeMorgan was a kind of tutor to her.

One time he wrote to Ada's mother, Lady Byron:

> *I feel bound to tell you that . . . (Ada's) power of thinking on these matters . . . has been something so utterly out of the common way for any beginner, man or woman (that) . . . Had any young beginner, about to go to Cambridge, shown the same power, I should have prophesied (that he would become) . . . an original mathematical investigator, perhaps of first-rate eminence.*

Romance

Finally, Ada was able to meet her heroine, Mrs. Somerville. The older woman became very fond of Ada. Ada was invited to attend concerts and plays and even to stay overnight with the Somervilles. Woronzow Greig, Mrs. Somerville's son by her first marriage, and her two daughters, Martha and Mary, made up their group.

One day a Cambridge friend of Woronzow's, whose name was Lord William King, came to call.

At this time Ada was a lively young woman who looked like her handsome father. She had "large, expressive eyes and dark curling hair."

Lord King fell in love with Ada and she with him. They became engaged to be married. Eleven years older than Ada, and of a serious nature, he wrote love letters that were full of tender feeling. Long engagements were not in style and the two were quickly married. Ada was nineteen years old and her husband was thirty.

Home and Family

Their first child, Byron, was born a year later. The following year a daughter, Annabelle, was born, and soon after, a third child, Ralph, came into the world. From then on, Ada's health was never good for long. The symptoms of mystifying illness that she had shown as a young girl--symptoms that were beyond the skill and understanding of the doctors of her day--now showed up again. She had digestive trouble and developed kidney disease as well as heart trouble and asthma. Between these attacks, however, Ada felt optimistic and continued to search for ways to pursue her mathematics career.

As a home manager, Ada was not successful. She loved her children, but hated the interruptions they caused in her work. Although she and her husband were aristocrats, and much of the time they kept servants, tutors, and governesses, they were not wealthy, and sometimes day-to-day duties fell to Ada. So eager was she to rid herself of these domestic chores and make time for her mathematical work that she begged her mother, who was always ready to take over, to take the children off her hands.

Three years after their marriage, Lord King inherited another title. He became Earl of Lovelace and Ada became the Countess of Lovelace. Although this title brought them no more money, Lord Lovelace was given a place in the House of Lords in Parliament.

The Analytical Engine

Babbage was working on plans for a far more complex machine which he called the Analytical Engine. Indeed, the large-scale electronic digital computers of our own century copy the logical structure of Babbage's Analytical Engine, which he thought up in the 1830's.

Ada's enthusiasm for this computer matched Babbage's. Another admirer of Babbage's, L. F. Menabrea, wrote an article in French describing the Analytical Engine and its principles of operation. Since Babbage had not written about his machine, this work filled a real need. Ada translated Menabrea's article into English and, in the process, expanded the contents in important ways. Her notes, three times the length of the original article, set down in concrete terms the powers and limitations of the machine.

A Published Work

The work was published, and Babbage proudly distributed copies to the leading scientists of the time. He was tremendously impressed with Ada's paper, and asked her why she had not written a separate original article on the subject. She replied that the thought had not occurred to her. To do such a thing seemed out of the question. In fact, even signing her own work brought her great anxiety.

Although her paper was clearly the work of an expert, it was also the work of a woman and a woman of rank at that. For such a woman to publish a scientific article was highly unusual. It was even more unusual when the area in question was such an "unfeminine" one as mathematical computation. After much indecision, Ada signed her paper "A.A.L.", using her initials only. It was many years before the author's identity was commonly known.

Babbage proposed using punched cards for putting data into the Analytical Engine. This was similar to the clever method invented by J. M. Jacquard, who used punched cards to control the sequence of threads in a loom in order to weave fabulous fabric designs.

Ada saw an equal beauty in the Analytical Engine, and she wrote: "We may see most aptly that the Analytical Engine weaves algebraical patterns just as the Jacquard loom weaves flowers and leaves."

Ada's paper provided the public with the best account of the machine, an account which Babbage saw was far clearer than he himself could possibly have done. As it turned out, this paper was the summit of Ada's career. No one knew why she never went on. Her health was bad, and somehow she could not focus her attention on intellectual problems.

Musical Ambitions

She wrote to Woronzow Greig: "I am not dropping the thread of science, Mathematics, etc. These may still be my ultimate vocation. . . Although it is likely to have a formidable rival . . . musical composition."

Ada was a promising musician. In her paper on the Analytical Engine, she suggested that the computer might be used to compose music, "if," she wrote, "the fundamental relations of pitched sounds in the science of harmony and musical composition were susceptible of sufficiently precise formulation."

Ada predicted computer music a whole century before it was actually produced!

Health and Money Troubles

But she was really not well enough to work at either music or mathematics. She wrote to Woronzow:

> *There is in my nervous system such a want of all ballast and steadiness. . . And I am just the person to drop off some fine day when nobody . . . expects it. . . Do not fancy me ill. I am apparently very well at present. But there are seeds of destruction within me. This I know.*

Ada swung between feelings of doom and exuberant joy and optimism. Her husband was different. The life of this ordinary mortal was wrapped up in the management of his estates. Developing and maintaining them was an expensive matter, and Lord Lovelace was not generous with money for other things.

He gave Ada 300 pounds yearly (or what would today be $840). This amount was part of her marriage settlement, a substantial 16,000 pounds (about $45,000). The entire sum was placed in a trust for her and would come into her hands only upon the death of her mother, Lady Byron. A much larger fortune, the bulk of her mother's large estate, would go directly to her husband, Lord Lovelace, according to the inheritance laws of the time.

As the only child of a very rich woman, Ada resented the small amount she was expected to live on. Her husband, she pointed out, would receive 7000 pounds per year--a sum, she wrote, "he is to enjoy to my exclusion!" Ada, it turned out, had reason to be concerned about money.

Playing the Horses

Perhaps Ada's greatest love was horses. When she was seventeen, she tried to avoid going on a vacation to Brighton resort because she had just got a new horse named "Sylph," and she so much wanted to ride instead. Lord King was an excellent rider, and the two of them loved to ride together.

Ada's passion for horses was now combined with another passion--gambling. Ada was a compulsive gambler; she could not quit once she started. She began to bet larger and larger amounts of money on horse races. She lost heavily. Part of the problem was her pride in her mathematical genius. She kept working on new formulas to help her figure the odds and pick a winner. It was common gossip that she and Babbage were fellow conspirators in choosing horses to bet on.

Since Ada had no control over the family purse strings and her husband did not approve of her large-scale gambling, Ada turned to "shady" money lenders to help meet her debts. These people blackmailed her, probably with the threat of telling her mother--her do-good, sin-hating mother.

Desperate for money, Ada pawned the family diamonds--not once but twice. Yet the debts kept piling up.

Tragedy's Path

Bad luck seemed to attract more bad luck, and Ada's illnesses returned with renewed force. She began to bleed internally. A tumor was found in her uterus. Cancer! And the doctors of the day knew of no cure.

Ada was crushed though she did not give up hope. Between bouts of intense pain, her spirit showed itself again and again. She had her bed moved near her beloved piano, and each day she played. Sometimes she played duets with Annabelle, her daughter, who was now fifteen years old.

Ada's mother moved into the Lovelace home, and from that time onward, visitors were not permitted to see Ada. Now, Ada could not leave her bed. Babbage in particular was kept away. Ada's mother felt bitter that it was his maid who had carried Ada's bets to the bookmakers.

Ada herself never lost her affection for Babbage. Lord Lovelace wrote in his journal eleven months before her death: "Babbage was a constant intellectual companion and she ever found in him a match for her powerful understanding, their constant philosophical discussions begetting only an increased esteem and mutual liking."

The Final Resolution

Now, of course, Lady Byron knew all. Ada's gambling losses could no longer be kept secret. Lady Byron paid out 5000 pounds ($14,000) to cover her daughter's losses.

Daily, Lord Lovelace struggled with his grief and with Ada's creditors, who came for their money--to the house where she lay dying. Ada's agony stretched out for nearly four months while her helpless family waited. Finally, two weeks before her 37th birthday, Ada died.

"By her own wish," a descendant wrote, "they carried her to the old Newstead country, and laid her by the father whom she had never known."

Ada's Influence

In the short years she lived, Ada Lovelace distinguished herself as a mathematician, and has even been called the inventor of computer programming. She used her gifts against tremendous obstacles and showed a spirit that would not be crushed.

As to Babbage and the influence of his Analytical Engine, his biographers wrote, "The Analytical Engine was never built, though Charles Babbage lived nearly another two decades. . . The Menabrea/Lovelace paper remains as the sole witness of the power and scope of the ideas of Babbage's Analytical Engine . . . these ideas . . . lay dormant for another century."

In a similar way, the Lovelace paper remains the sole witness of the power and scope of Ada Lovelace's special genius. Now, a century later, we marvel at her early contribution to the machines of our own day.

TRIANGULAR NUMBERS

The **triangular numbers** are the sums of the counting numbers 1, 2, 3, 4, . . . (See page 111, **Pascal Triangle**, for more about these numbers.)

Complete the first 20 triangular numbers listed below.

To calculate the numbers, use the information that $T_2 = N + T_1$, where T_2 = next triangular number; N = first (1), second (2), third (3), etc. counting number; T_1 = previous triangular number.

Triangular Numbers

N	+	T_1	=	T_2
1		0		1
2		1		3
3		3		6
4		6		10
5		10		15
6		15		—
7		—		—
8		—		—
9		—		—
10		—		—
11		—		—
12		—		—
13		—		—
14		—		—
15		—		—

Use this list of triangular numbers (T_2) to complete the portrait of Ada Lovelace on page 20

A BIT OF BASIC

Many people consider Ada Lovelace to be the first person to describe what is now known as computer programming. A new programming language has been named after her. The language is called ADA. It was developed by the United States Department of Defense (DOD). The DOD hopes ADA will be adopted as a universal programming language. They hope it will replace the babble of languages now being used, and will make sharing programs much simpler.

BASIC is a language that is very popular now. Most microcomputers understand a version of BASIC. However, even this simple language is slightly different from computer to computer.

The following activity explores a few simple statements in BASIC. To do this activity, you need to have access to one of four popular microcomputers: APPLE, TRS-80 (Radio Shack), ATARI or PET (Commodore). This activity will introduce a program that works on each of these machines.

You need to learn three commands: NEW, LIST, RUN.
These commands speak directly to the computer.
You need to know three statements, or words: PRINT, GOTO, END.
These statements are part of the program and require line numbers.

First turn on the machine.
APPLE: Switch in back, left. (If you have a disk drive connected to your Apple you may need to press RESET to get the disc drive to stop whirring)
TRS-80: Switch in back, right.
ATARI: Switch on right side.
PET: Switch in back, left.

NEW and LIST

Type NEW and then hit RETURN. NEW tells the computer to clear its memory. Hitting RETURN is very important to remember, and often hard for the new user to remember. Hitting **RETURN** tells the computer you have completed your part, and it is the computer's turn to do its part.

Next, type **LIST** (and hit **RETURN**). **LIST** tells the computer to show what is in memory. If the new command worked properly, the **LIST** command will now show a blank screen.

PRINT, GOTO, and END

You are now ready to write a program.

To write a program you will need to write **LINE NUMBERS**. Any numbers will do, as long as they are in sequence. However, it is good practice to leave gaps between numbers in case more lines need to be added later.

For example, line numbers could be 10, 20, 30, ... or 100, 200, 300, ... or 110, 120, 130, ...

It would be a poor idea to number lines 10, 11, 12 ... or 101, 102, 103, etc.

The **PRINT** statement will cause any string of letters, enclosed by quotation marks, to be printed on the screen.

The **PRINT** statement can end with no punctuation mark, a **comma**, or a **semi-colon**. Later, we will see the different ways the screen will look when you use any of these.

The **GOTO** statement does what you have probably guessed it does. It is always followed by a line number, and it tells the program to jump to that line number and perform the statement at that number.

The **END** statement tells the computer that the program has ended.

Type the following program exactly as you see it.
Don't forget the quotation marks.
Don't forget the semi-colon.
Don't forget the line numbers.
Don't forget to hit **RETURN** at the end of each line.

```
10 PRINT "TEASE"; (hit RETURN)
20 GOTO 10
30 END
```

When you have completed the typing, type **LIST** (and hit **RETURN**).

Does the screen echo what you have typed?

If you see a mistake, retype the line, including the number.

STOP: CTRL C and BREAK

Before you type **RUN** to execute the program you had better know how to **STOP** the program. To **STOP** the program:

APPLE: type **CTRL C**. (Hold down the control key as you type C. This button works like the shift key on the typewriter.)

TRS-80: Hit **BREAK**

ATARI: Hit **BREAK**

PET: Hit **RUN/STOP** key

RUN

Now type **RUN** and watch the screen fill. Wow!!!

Stop the program.

Type **LIST**.

Retype Line 10. This time leave out the semi-colon.

Run the program again. How does the screen look now?

STOP the program. Type **LIST**.

Retype Line 10 again. This time put a comma at the end of Line 10.

Run the program. How does it look now?

STOP the program. Type **LIST**.

Retype Line 10 again. This time put the semi-colon at the end of the line again.

Run the program.

You can fill the screen with attractive designs using the **PRINT** command, as you did in this program.

When you use the semi-colon in your **PRINT** statement, sometimes your message is printed in neat columns, sometimes it is printed in diagonals that set the entire screen in motion.

Can you predict when columns will appear; when diagonals will appear? Here is a hint! Each computer has room for a different number of symbols across its screen:

APPLE: 40 columns wide
TRS-80: 64 columns wide (Model 1 or 3)
ATARI: 36 columns wide
PET: 40 columns wide

When the number of letters and spaces inside the quotes of the **PRINT** statement is a multiple of the number of symbols across the screen, the screen will fill with columns. When the number is not a multiple, the screen will fill with moving diagonals.

For example, Apple's display is 40 columns wide. Print "CANDY" will fill the screen with 8 columns of CANDYs since CANDY had 5 letters and 5 times 8 is 40. If one or two spaces are added after CANDY, the screen will fill with a moving diagonal display since 6 and 7 are not multiples of 40. Try it and see.

Try running your program again using different lines 10. (Remember to copy them exactly as you see them. Do you remember how to **RUN** and **STOP** your program?)

```
10 PRINT "TEASE";
10 PRINT "*TEASE";
10 PRINT "*TEASE*";
```

Add an extra line; for example **15 PRINT "POP*";**
See how the program runs now.

Change the punctuation.
Try your name.
Try your friend's name.
Print any patterns of letters or words or symbols between the quotes.

The **GOTO** statement explained on page 32 makes the computer run the **PRINT** statement continuously, or until the program is stopped from outside. When a statement makes a program go round and round in this way, we say the program is in an **infinite loop.**

Are you ready to try a program that is slightly more complicated? Here is a program like the one you have just done, but here you tell the computer exactly how many times you want it to run the PRINT statement.

FOR/NEXT LOOPS

The **FOR/NEXT** statement controls the number of times the **PRINT** statement will be run.

The **FOR/NEXT** statement is 2 lines long and is "sandwiched" around the statement or statements that are to be repeated.

```
10 FOR N = 1 TO 100
20 PRINT "TEASE*";
30 NEXT N
40 END
```

Run the program.

Lines 10 and 30 are the "bread." Line 20 is the "filling."
Line 10 tells how many times the "filling" will be repeated.
Line 20 is the "filling."
Line 30 moves the counter in line 10 along from 1 to 100.

When the counter shows the **PRINT** statement has been run 100 times, the program drops to Line 40, and **ENDs**.

Play around with this program.

N can be any letter. Try it.

Change the letter and the number in line 10 to ... **FOR N = 1 to 100 ...**

Try a different message in Line 20.

Try the message with and without a comma; with and without a semi-colon.

Remember to hit **RETURN** after you complete a line or when you type a command to the computer.

Play around with these commands.

Go to a book store or a computer store and find a book you like that will teach you more about BASIC.

Ada Lovelace would be proud of you!

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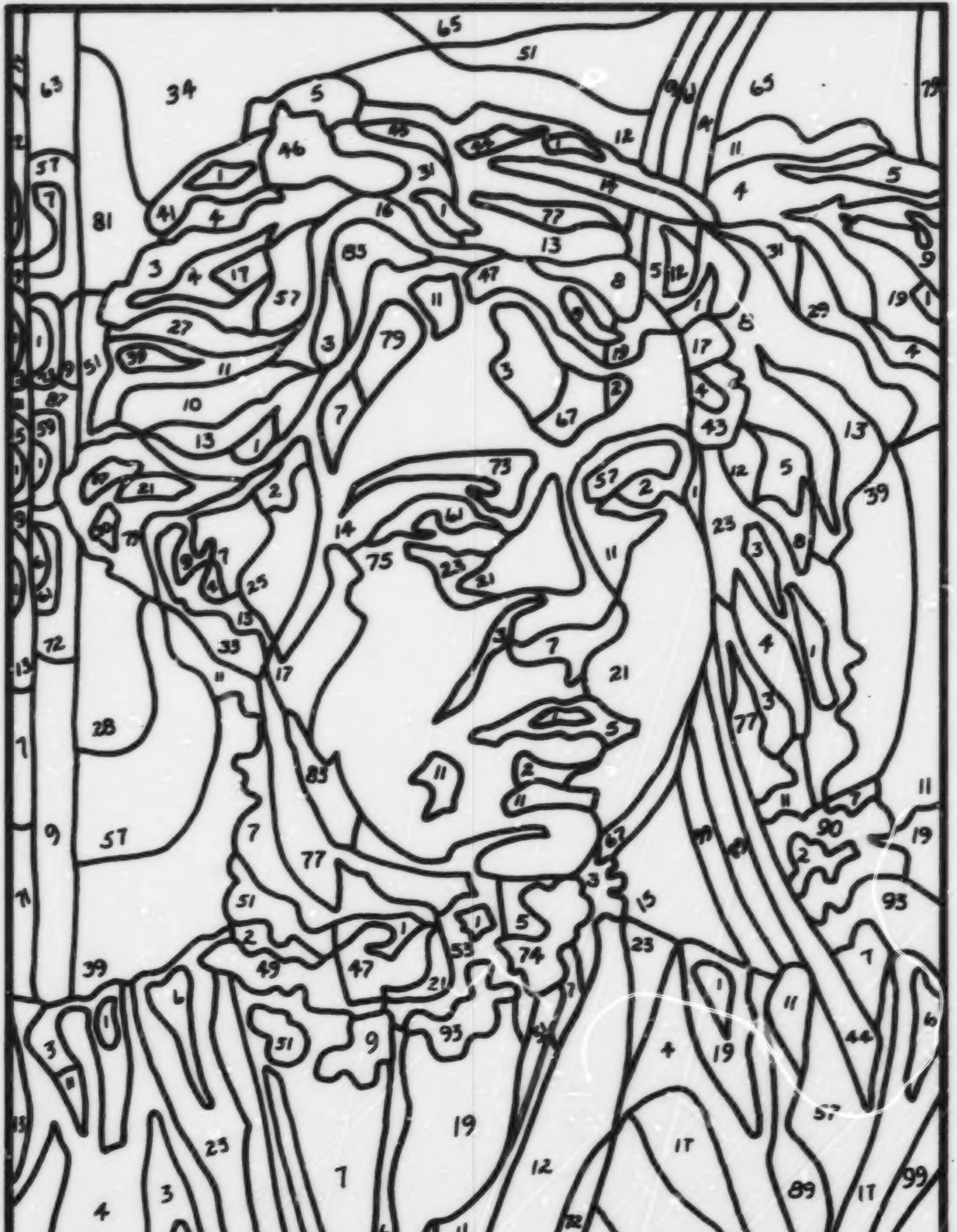
SONYA KOVALEVSKAYA **SHADE ALL PRIME NUMBERS**



SONYA KOVALEVSKAYA

1850-1891

Sonya Kovalevskaya was born in Russia at Palibino, a large estate in Vitebsk. In winter, wolves howled around the estate, and deep snow buried the road to St. Petersburg, the nearest large city. Pine forests protected the large house from the winds that blew over miles of plain.

Indoors, the family lived in a private world. Head of the household was General Krukovsky, Sonya's father. Her mother was much younger than the General; she liked to read novels, to paint and play the piano. Aniuta, Sonya's sister, was six years older, and Fedya, her brother, was three years younger.

A Strict Schooling

From the time Sonya was five years old until she was twelve, she had only one teacher, an English governess. This woman did not understand Sonya's passionate Russian nature. She tried to press Sonya into a mold labeled "proper English miss"--a mold that would produce a young woman who played the piano, had perfect manners in company, and was neat, tidy and prompt. She would not let Sonya read romantic novels and poetry as she loved to do, and she urged long winter walks on her, to improve circulation! Sonya escaped this torture only when the temperature fell below 10 degrees.

The governess held total power over young Sonya's life. Her father felt it was not his place to make decisions about Sonya's education, and her mother was not strong enough to go against the governess' rules. Sonya felt her parents did not really care about her.

More and more, the person to whom she showed her affectionate heart was her teenage sister, Aniuta. Because Aniuta and the governess despised one another, Sonya had to sneak when she wanted to see her sister.

The Krukovsky house was quite large, and each section was occupied by a part of the family. Sonya's father lived in the tower, her mother and sister lived upstairs in the main apartments, Fedya and his tutor lived in a separate upstairs wing, and Sonya and her governess lived on the ground floor.

Studying the Wallpaper

All of the rooms were decorated with fancy imported wallpaper. Only one was left unfinished. In this room the imported wallpaper ran out, and old papers were used to cover the walls. These papers were lecture notes which the General used in his student days. The subject was differential and integral calculus. Sonya was alone a great deal, and she amused herself by staring at the squiggles on the papers. Years later, she studied calculus in St. Petersburg. She caught on so quickly her teacher remarked that she must have known the subject all her life. In a way she had.

Sonya was a brilliant student. After her governess left, she taught herself physics. But in order to do this, she found she would need to learn trigonometry. So she taught herself!

A friend of the family was a physicist. One time, visiting the Krokovskys, he questioned Sonya about her studies. When he learned what she was achieving, he went to the General and convinced him that Sonya must be allowed to study mathematics in St. Petersburg. The General finally consented.

The World Outside

Sonya was growing up at a time of great social and political upheaval in Russia. In 1861, Czar Alexander II gave the serfs their freedom. Ideas about equality for all spread even to the country--to the estate at Palibino.

A young man from the nearest village struck up a friendship with Aniuta. He had been living in St. Petersburg and learned the new political ideas. He brought magazines and journals that told of the struggle for freedom from hunger, poverty and harsh rule all over Europe. They told of the serfs' desire for equality, of women's desire for higher education, and the people's desire for political power.

Many sons and daughters of the aristocracy, like Sonya and Aniuta, criticized the old-fashioned ideas of their parents. They were just beginning to understand that they could not continue their comfortable traditions--marrying early and settling into their role as upperclass landowners.

A Wild Plan

Aniuta, Sonya's sister, was now a grown-up young woman, longing to be free of her father's strict rules. Yet she was stuck at Palibino. She asked her father if she could study at the University of St. Petersburg and her father said no.

At this point, around 1860, the University had just opened classes to women, although women could not earn degrees. A couple of years later, when students protested in order to gain more liberties, the University closed. When it reopened, women were no longer permitted to attend classes there, nor anywhere else in Russia.

Sonya, like Aniuta, wanted to leave home. She wanted to study science at a university. Wherever Aniuta went, Sonya decided, she would follow.

Together with Sonya and a friend, Aniuta devised a wild plan. The young women would ask a young man who shared their political beliefs to marry one of them! Such a marriage would set them free. Once they were married, the couple, plus their friends, would set off to study at a university in Germany or Switzerland. In these countries, women had a better chance of being admitted to universities.

Such a marriage, it was understood, would be in name only. After their arrival in the foreign city the husband and wife would live apart.

The first young man they tried to interest in their plan turned them down. But one more "no" did not discourage these three. Next, they tried a promising student of geology. His name was Vladimir Kovalevsky. This young man said "yes."

There was one problem: he wished to marry Sonya, the youngest. He wrote to his brother, "Despite her eighteen years the Sparrow (Sonya's nickname) is extremely well-educated. She speaks foreign languages as fluently as her own. She studies mainly mathematics, is now tackling spheric(al) trigonometry and integrals. She is as busy as a bee from morning till night and still is lively, sweet, and very pretty."

To this bold marriage proposal the General said, "No"! It was unheard of that a younger sister marry before the older. But Sonya had seen her chance to escape and follow her dream of getting a higher education.

Sheer desperation gave her the courage to do what she did next. She, who was never allowed outside her home unchaperoned, slipped away to join Vladimir in his apartment in the nearby village. According to the rules of the society in which they lived, such behavior was equal to eloping. She left a note for her father, telling him where she was going and why. He followed her there. As she had hoped, her father now allowed their engagement.

Sonya and Vladimir were married with her family's blessing, and within six months, the couple was living in Germany.

Higher Education

During the two years spent at Heidelberg, Germany, Sonya's closest friend was Julia Lermontov, a student of chemistry. Lermontov later wrote about Sonya during these years: "She was just eighteen but looked much younger. Small, slender, with a round face and short curly chestnut hair, she had very mobile features. Her eyes, especially, were exceedingly expressive--sometimes bright and dancing, sometimes dreamy and full of melancholy . . . a mixture of childish innocence and deep thought . . . She took no pains about her personal appearance or dress . . . a trait which remained with her to the last."

According to plan, Sonya became a student in mathematics at the university, and began her climb to fame and honor and, along the way, to tragedy and heartbreak.

Sonya was a daring idealist who was concerned with bettering human life. She also loved society and its honors. In the other side of her life, she was a lonely scholar living for her work, avoiding other people who would bring desires and disappointments.

Sonya always felt a hunger for love. Her own life, she believed, was terribly lacking when she observed the lives of her friends. As in her childhood, she now felt she was somehow outside circles of love.

Sonya moved to Berlin in order to work under the famous mathe'ma'ti'cian, Karl Weierstrasse. Here she spent four years, finally receiving her degree in mathematics from the University of Gottingen in 1874.

She worked during this period in almost absolute solitude, often sitting for hours in her room trying to solve problems. When she succeeded, she would rise from her desk and pace the floor talking to herself, walking faster and faster, laughing and finally breaking into a run!

The calm satisfaction of a Mary Somerville she did not have. Rather, Sonya was nervous and withdrawn. She saw no one for days. She went neither to parties nor dinners.

Vladimir, her husband, also lived in Berlin during this period. When he visited Sonya, they would go for long walks. This was her only recreation.

Sonya frequently went back to Russia. From there she once wrote, "I feel released from the prison in which my best thoughts were in bondage. You cannot think what suffering it is to have to speak always foreign languages to your friends. You might as well wear a mask on your face."

Married Life

After five years of a marriage that was a mere business arrangement, Sonya and Vladimir became lovers. True to her passionate temperament, Sonya threw herself into married life, hoping the marriage would succeed as a love match. She also hoped it would produce the happy family life she longed for.

A daughter was born who was also named Sonya. But she was known by her nickname, Fouzi. Sonya put aside all of her studies to care for little Fouzi and to promote her husband's scientific work. She yearned to be a typical wife and mother. But she was not typical. When Vladimir, a lecturer in geology at the University of Moscow, began to lose interest in science, Sonya wrote his lectures for him. Instead of attending to his job, Vladimir plunged into business schemes. They failed, one after another.

Sonya believed she had the power to see the future. One night, she had a nightmare that a grinning monster was stamping Vladimir beneath its feet. She was terribly frightened. Later, she realized that the dream monster was Vladimir's business partner. This man cheated Vladimir out of a large sum of money. Through his persuasion all the family money, including Sonya's small inheritance from her father, was invested in Russian oil refineries. The refining company was later accused of fraud, and Vladimir was threatened with a lawsuit. While this was happening, the partner convinced Sonya that Vladimir was in love with another woman.

Sonya felt rejected. She left Russia with her daughter and returned to Berlin. There, in a hopeless state of mind, she threw herself once again into mathematics.

Vladimir committed suicide. Sonya was just thirty-two years old, and already a widow. The death of her husband was a great blow. She never stopped feeling somehow responsible for his sad end.

Professor Sonya

In the next ten years, Sonya came into her own. She became a respected mathematician. Her teacher, Weierstrasse, introduced her to Gosta Mittag-Leffler, a Swede, who took up her cause. Mittag-Leffler got her a job as mathematics professor at the University of Stockholm in Sweden. This was a tremendous step forward for Sonya, and for women of science!

The first year, many parties and balls were given in her honor. Swedish girl babies were named "Sonya" after her. After all, she was the only woman professor in the country!

But Sonya had enemies as well as admirers. A famous Swedish writer, August Strindberg, wrote a scornful article about her appointment.

Sonya repeated what he wrote in a letter to a friend. "She proves, as decidedly as that two and two make four, what a monstrosity a woman professor of mathematics is, and how unnecessary, injurious and out of place she is."

Nevertheless her career went so well that she was given a five-year contract in 1884 and asked to become a professor of mechanics, a branch of physics. When she accepted this second job, she joked, "Now I have become a professor squared!"

Mittag-Leffler's sister, Anna Carlotta, a well-known writer, became good friends with Sonya. Sonya now began a second career as a writer. Her themes were mainly about her childhood in Russia.

Both women were feminists and held high hopes for the future of women in the world. The "woman issue," as it was called in Sweden, was a subject of hot debate at that time.

The two women began to work on a drama in two parts, called "The Struggle for Happiness: How It Was, How It Might Have Been." Sonya was so excited about this work that she gave up mathematics for a time. She and Anna Carlotta dreamed about traveling to Germany and France to meet literary and theatrical stars and prepare for their coming fame.

They promised to write each other's biographies. With that in mind, they both began saving letters and documents.

It wasn't long, however, before Stockholm began to seem like a boring country town to Sonya, and one that was desperately cold in winter to boot. Sonya longed to live in a dazzling world capital like Paris. But she needed a job, and women mathematicians were not wanted in many universities--in almost none in fact. Rarely were women allowed to be students, much less paid teachers. Sweden was the only country in Europe, except for Italy, where there were women professors in any subject.

Sonya tried again to find work in Russia. After years of being ignored in her native country, she was made an Associate of the Russian National Academy of Sciences. So, with hopes high, she visited her homeland.

There, she heard of a job teaching mathematics in a girls' high school. When she inquired about it, the Minister of Education told her the position was too inferior for someone of her importance. More likely, she was turned down for two other reasons: the first, because she was a woman; second, because as a teenager she had worked with Aniuta and other students who wished to upset the Czar's government. Back to Stockholm Sonya went.

Now, almost as soon as one disappointment occurred, another followed--too fast to lessen the shock. Sonya was carried along, from grief to despair to death.

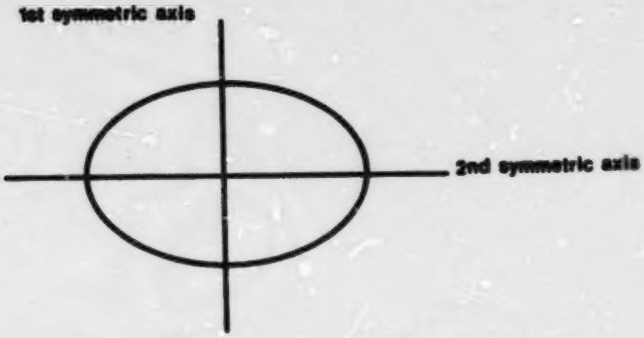
Her book, *Struggle for Happiness*, failed in Sweden. Her beloved sister Aniuta, whom she had called her "spiritual mother," died after a long and painful illness. Sonya buried herself once more in mathematics.

Prix Bordin

Sonya decided to compete for the greatest mathematics prize of the time, the Prix Bordin, offered by the Paris Academy of Sciences. All during the summer of 1888, Sonya worked on the problem she had set herself, staying up all night many times. The title of her research was "The Problem of the Rotation of a Solid Body About a Fixed Point." The subject was the form of Saturn's rings.

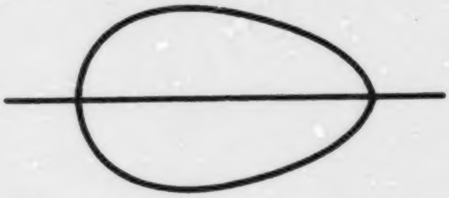
Mathematicians try to write equations that will describe certain situations that occur in nature, such as the rotation of the earth around the sun. Some of Sonya's most important work involved the study of the shape and behavior of Saturn's rings. This is particularly timely today, for at this very time scientists and non-scientists alike are holding their breath with excitement as Voyager I rushes past Saturn. Photographs are being broadcast which will confirm Sonya's research or add new puzzles.

Before Sonya's work scientists had considered the shape of Saturn's rings to form an ellipse. An ellipse is a special oval shape that has two axes of symmetry.



An axis of symmetry is a line across which you can imagine folding an object and fitting it perfectly on the opposite side.

Sonya proved that the cross-section of the Saturn ring must be egg-shaped. Such a shape, like a lengthwise slice of egg, is symmetric along only one axis instead of two.



Notice that if you fold the figure horizontally, the two parts are exactly the same. But if you try to fold the figure on a vertical axis, the two parts won't fit.

Sonya's conclusions about Saturn's rings may or may not be confirmed by the pictures sent back from Voyager I. But the work she did still stands.

A Great Prize

After putting out tremendous energy on her research on Saturn's rings, Sonya submitted her work to the Paris Academy of Sciences. On Christmas Eve, 1888, she was named the winner of the great prize! Along with it, she received 5000 francs, an increase of 2000 francs over the usual amount, because her work had solved a problem that was so important to the mathematics of that time.

A Love Affair

During this same year, 1888, Sonya fell in love. The man's name was Maxim Kovalevsky. She called him "Fat Maxim" in tones of proud affection.

Maxim was a Russian lawyer who was fired from the University of Moscow in Russia because he criticized Russian constitutional law. This was like criticizing the Czar himself. Neither he nor Sonya could go back to Russia and make a living.

Sonya and Maxim had many fights. She was jealous and possessive, and she went from love to anger, and back again, over and over. Maxim taught at universities mainly in France and often he left Sonya. When they were apart, Sonya felt utterly abandoned. Maxim turned up faithfully when she received the Prix Bordin in Paris.

Even while she was being honored in Paris, she was very unhappy because of her love troubles.

She wrote a friend, "Letters of congratulation are pouring in from all sides, but . . . I am as miserable as a dog. No; I hope, for their sake, that dogs cannot be as unhappy as human creatures, especially as women."

A couple of years passed, and again it was the middle of a long, harsh winter. For the Christmas vacation, Sonya went with Maxim to Naples. There, escaping from her bleak life in Stockholm, she spent many happy weeks with Maxim in the sunny atmosphere of Italy. She wrote to her daughter that the view from their veranda showed a garden "Blooming with roses, camellias and violets, and oranges ripening on the trees."

At the end of the vacation, the couple separated and Sonya was alone on the trains going north. The weather was cold and rainy and she caught cold.

The end was swift: from cold to inflammation of the lungs to pneumonia. In three days, she was dead. She was only forty-one years old. The evening before she died she said, "I feel as if a great change has come over me." Face to face with death, she was suddenly at peace.

The brother of Gosta Mittag-Leffler wrote a poem about Sonya. He called her the "Muse of the Heavens." He wrote:

While Saturn's rings still shine,
While mortals breathe,
The world will ever remember your name.

We do indeed remember her name today.

PRIME NUMBERS

Shade all prime numbers to complete the picture of Sonya Kovalevskaya on page 38.

For this activity it is convenient to have a list of **prime numbers** handy. If you don't have such a list, try the following activity. It is called the Sieve of Erosthenes, after the Greek mathematician who supposedly made up the idea.

Make the following modifications to the number grid on page 49

- Draw a square around $\boxed{1}$. Then remember that 1 is not a prime number.
- Draw a circle around ②. Two is the first prime number. Two is also the only even prime number.
- Now draw a horizontal line (——) through all multiples of 2. This will be all the other even numbers.
- Draw a circle around ③, the next number that has not already been crossed out.
- Now draw a vertical line (|) through all multiples of 3.

Notice the numbers crossed out with both vertical and horizontal lines. These are the **common multiples** of 2 and 3. These are also the multiples of 6.

- Draw a circle around ⑤, the next number that has not yet been crossed out. Now draw a diagonal line (/) through all multiples of 5.
- Next draw a circle around ⑦, the next number that has not previously been crossed out.
- Draw a diagonal line going the other way (\ ) through all multiples of 7. (You are just about done.)
- Go through the grid and draw a circle around every number that has n[illegible] been crossed out.

These circled numbers are all the prime numbers between 0 and 100. Keep this page handy. All the prime numbers you will need to shade are circled here.

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70
71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100

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MARY EVERETT BOOLE

1832-1916

The two children crouched down in the soft morning rain. The girl poked under a leaf with a stick. The boy, smaller than she, pushed aside some wild grass.

"Regardez!" the boy exclaimed, "un papillon." (Look! A butterfly.)

Its wing was torn. The girl carefully carried the creature inside the house. Taking turns, they blew on it to warm it.

Mary and her brother George often nursed insects that had been hurt by the frost or rain. Then they kept them for "pets." These and an occasional lost dog were the only pets the children were allowed to have.

Their father, Thomas Everest, a minister, was seriously ill. He was under the care of a famous doctor named Samuel Hahnemann. Though Mary and George had been born in England, they moved to the small village of Poissy in France when Mary was five and George was two years old.

Dr. Everest's cure took six years. Life was lonely for the children in Poissy. They belonged to an English minister's household while everyone else in the town was a French Catholic. Also, the Everests did not approve of French politics of that time. The laws of the French monarchy were harsh toward the people. Their father's illness worried both of their parents. Servants looked after Mary and George, but the two children were mostly on their own.

The Leaves and the Root

Mary was a bright child, outgoing and talkative. "You were the roots and I the leaves of the plant," she wrote to George when both were old.

Little George was his sister's fan. When Mary was nine, she wrote a play, and George, who acted in it, boasted, "C'est ma soeur qui a invente cela." (My sister made that up!)

Homeopathy

Their father was a great believer in homeopathy, a medical system promoting health and preventing disease. Dr. Hahnemann was the founder of homeopathy, and Mary's father was devoted to his system. Followers of homeopathy practiced some extreme customs, and in the Everest household, Mary and her brother George had to practice them too.

They took long walks before breakfast in freezing weather and baths in ice water to help them resist disease. Some thought the cure was worse than the disease. But Mary was loyal to her father and submitted to whatever experiments he dreamed up without complaining. An ill person himself, he was determined that Mary and George would grow up to be healthy.

Mt. Everest and Uncle George

Mary's family name was made famous by her uncle George Everest. George was a surveyor who spent twenty years in India. Because he led a survey team up the great mountain, Mount Everest was named for him.

Uncle George did not often visit his brother's family, but when he did, he brought tales of adventure in far-off places. Mary was a great favorite of this uncle, and he wanted to adopt her. But she was too attached to her parents to agree. Mary was very close to her father, and for as long as he lived, she was his devoted assistant.

Mary and her brother George were always being scolded for quarreling. George spent every French "sou" he got while Mary was a "pinchpenny." Their father saw to it that they didn't quarrel over money by giving them a joint allowance. Somehow, because of their common piggy bank, George became more cautious about spending, and Mary became more generous.

A Crush

Mary had a tutor from the village. Monsieur Deplace taught Mary every morning from 6:00 to 8:00. No lying abed for an Everest child!

From the first day, Monsieur Deplace made arithmetic clear to Mary. When her mother had tried to teach her long division, it was a mess! With Monsieur Deplace, learning was easy. He asked her a series of questions. Then he told her to write down the answers. When she read them aloud to him, she realized she was reading certain orderly steps that would solve her problem. Mary never forgot this wonderful way of learning.

Mary had a crush on Monsieur Deplace. Although he was pleasant, he never showed her affection. Still, she felt she was someone special to him, and she remembered him all her life.

The Rector's Assistant

When Mary was eleven, her father regained his health at last, and the family went back to England. Her father became rector of a church at Wickwar, at the foot of the Cotswold Hills. Mary was taken out of school and became her father's assistant in his parish work. Her duties were visiting old people, teaching children in Sunday School and helping her father prepare sermons.

The Differential Calculus

For mathematically-minded Mary, leaving school did not mean an end to study. She taught herself calculus from books she found in her father's library. While she was teaching herself differential calculus, she became stuck and she looked around for some help.

"I soon found in the library an old book of Fluxions into which I plunged with delight," she wrote . . . "After I had been revelling in my prize for a week, my father found me with the book and took it away, telling me that the Fluxion notation was old-fashioned and inconvenient, and quite given up now at Cambridge." (Since women students were not admitted to Cambridge, Mary had no way of discovering this for herself.) "I went back to my differential book, and found, to my great delight, that it was now perfectly clear to me."

How could that be? This was a puzzle.

Mathematics, Friendship and Love

Two years later, when Mary was eighteen, she had a chance to solve the puzzle. She visited the home of her aunt and uncle who lived in Cork, in Western Ireland. Her Uncle John was Professor of Classics at the University of Cork.

One day, a young professor, a good friend of her uncle's, came to call and Mary was introduced to him.

George Boole was already a well-known mathematician. Mary told George about the differential calculus puzzle and how the old-fashioned method of learning calculus had helped her. George said the book of fluxions helped her by setting up certain orderly steps for her to follow, just as Monsieur Deplace had done so long ago. Using these steps, Mary was able to solve the problems in the regular calculus textbook.

Mary liked George Boole very much. He was a kind and understanding man, as well as being a mathematical wizard. Students and children loved him. After her return to England, she wrote to him. She sent him examples of her work in mathematics. Two years later George came to Mary's home in England and began to teach her a serious course in mathematics.

At this time, George was writing a book called *Laws of Thought*. When it was published two years later, it became a sensation among mathematicians and other serious thinkers. In it, he investigated the laws that govern the part of the mind which reasons about things. These laws were expressed in an algebra of zeros and ones. This algebra even today is called "Boolean Algebra."

Later, when George revised his *Laws of Thought*, Mary, with the help of George's students, read the manuscript. When he wrote something that was not clear, they told him so in no uncertain terms. Once, when he was composing a section on differential equations, Mary sent the manuscript back five times for re-writing! On the sixth time around, it was clear. George had passed inspection.

A Boolean Family

A few years later Mary's father died. In her grief, she turned to George for comfort and friendship. A year later, the two were married. Mary was twenty-three years old and George was forty.

"Into the next nine years," wrote a biographer, "were crowded a lifetime of events. Five daughters were born to them: Mary, Margaret, Alicia, Lucy and Ethel. It was a very happy marriage, and Mrs. Boole was able by her understanding care to safeguard her husband's health and protect him to a great extent from the effects of his constant and strenuous work."

Safeguarding her husband's health, as she had spent her youth safeguarding her father's health, seemed quite natural to Mary. Like most women of her time, she was devoted to her family, and raised her five daughters. But her life did not follow a set formula. Rather than moving along a straight line, Mary's destiny was to wind, bend and curve back and forth throughout her life.

Mary and George read many books together. They enjoyed the great English poet Milton and other poets and philosophers. The two talked about new ways to educate the young, taking what was best from Monsieur Deplace, from their experience with George's students, from Mary's own study, and from other thinkers. But they laid no plans for educating their own children.

Suddenly, George caught pneumonia and died. Mary's youngest child was six months old, and she herself was only thirty-two and a grieving widow. She had to go on alone.

What did she do? She went out and got a job!

The Wide, Wide World

In those days, this was a heroic task. Mary had no job experience except sermon writing and parish teaching and working with George's students. But there was the key--writing and teaching.

While Mary tackled her personal problems, turmoil was also stirring up the wider world. Revolutions had swept through Europe in 1848 and America was now on the verge of Civil War. It was 1864, and educational and political questions were boiling in England. The young widow's mind bubbled with them.

Mary had never lost the love of learning that led her to pursue her studies alone and seek out scholars like George Boole. George had been interested in the ideas of a man named Frederick Denison Maurice and wanted to invite Maurice to join their discussion circle. But George's illness and death prevented this plan.

After George died, Mary pledged herself to further George's work. When the opportunity arose (she had a problem on which she needed advice) she made an appointment to meet Maurice. Maurice was a lecturer at Queens College.

Queens College in Harley Street

Queens College in Harley Street, London, was founded in 1847. It was the first women's college in England. Its patron was Queen Victoria. Its purpose was to train young women to become governesses. Neither women nor Jews at this time were granted college degrees anywhere in England, but at least here women could study on a college level.

But Queens College wasn't giving anything away to women. Women could not receive degrees and no women could be appointed to the teaching faculty. The only jobs available were so-called "staff assistants." There was no direct teaching of students in these jobs.

When Maurice met Mary, the first thing he asked was if she would take a position as librarian at the College. Mary accepted and went to work.

Now she was in her element! Although she could not teach, she became a friend and advisor to the students. She organized what came to be called "Sunday Night Conversations."

Mary and the students discussed Boole's mathematics, Darwin's natural history, and psychology, and how each subject affected the others. They held logic-practice talks. Mary presided over the meetings. They were a smashing success.

"I thought we were being amused, not taught," a graduate wrote to her later. "But after I left, I found you have given us a power. We can think for ourselves, and find out what we want to know."

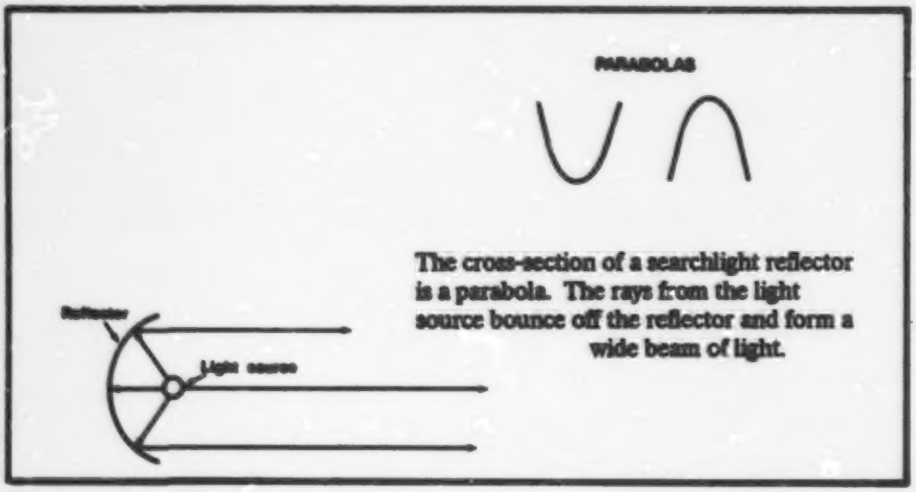
Mathematics As Fun

Mary began to teach children, using her own theories. She was most interested in showing how ordinary everyday activities prepared children to learn mathematics and science.

" . . . Children do things such as drawing or sewing, counting in tens . . . sharing an apple or painting a pattern on a wall. And in the unconscious (usually not to come into consciousness for years) is growing . . . (an understanding of) zero and infinity, adding or multiplying minus . . . and many other fundamental mathematical . . . (ideas)."

Natural materials and imagination: *that* was the magic combination to create excitement in mathematics class. Girls in her classes used needles, thread, and cardboard to form curves with long straight stitches. Boys used their penknives to cut twigs from hedges. They took elastic from hats and slats from cigar boxes to build three-dimensional figures.

One day the Head of the London Board of Education came to Mary's class. An eleven-year-old student demonstrated a toy the class had made together. It showed a parabola in the act of changing its rate of curvature. The official was "staggered" at the cleverness of the students.



The cross-section of a searchlight reflector is a parabola. The rays from the light source bounce off the reflector and form a wide beam of light.

Children, Mary believed, should "have the opportunity of watching. . . how one geometrical type-form grows out of, or flows into, another. A common night-light placed in the bottom of a deep round jar in a dark room throws on a sheet of cardboard held over it patterns of conic sections, which pass into each other as you change the position of the cardboard." Children love to watch the shadows change and it is good training for geometry, she advised.

Mary threw all these ideas together into a pot and out came a rich stew--a book called *The Preparation of the Child for Science* (which included mathematics).

Curve Stitching

Mary invented cards marked for the purpose of curve stitching. They were known as "Boole cards" in England. Mary happened upon curve stitching, or what today we call string geometry, by chance, and saw at once it could be an aid in learning about the geometry of angles and space.

"In my young days," she wrote, "cards of different shapes were sold in pairs, in fancy shops, for making needle-books and pin cushions. The cards were intended to be painted on; and there was a row of holes around the edge by which twin cards were to be sewn together. As I could not paint, it got itself somehow suggested to me that I might decorate the cards by lacing silk threads across the blank spaces by means of the holes. When I was tired of so lacing that the threads crossed in the centre and covered the whole card, it occurred to me to vary the amusement by passing the thread from each hole to one not exactly opposite to it, thus leaving a space in the middle. I can feel now the delight with which I discovered that the little blank space so left in the middle of the card was bounded by a symmetrical curve made up of a tiny bit of each of my straight silk lines; that its shape depended upon, without being the same as, the outline of the card . . ."

A book about experiments with curve stitching came into print. It was written by a friend of Mary's and was called *A Rhythmic Approach to Mathematics*. Cards with patterns from ancient times mysteriously appeared in the book.

"Some of the patterns reproduced designs in old Celtic art; others in old Egyptian and Greek art; in fact," Mary wrote, "we are hearing from various parts of the world . . . (People say) 'you have reproduced the ornamental work on such or such a very old building.'"

The designs in this book reproduced basic designs that were used in Egyptian, Greek and Celtic art! To Mary, this showed that people's unconscious minds were similar--no matter when or where they lived.

"Psychic" Science

In Mary's time, many people asked questions about the spirit world. They wondered whether it existed and, if so, how it worked. They used the word "psychic" for anything to do with the spirit world. Mary had long thought about psychic happenings. She completed a book and called it *The Message of Psychic Science for Mothers and Nurses*.

At this time, Maurice was her employer, and he was also a minister in the Church of England. Maurice prided himself on being a tolerant man, but he stopped short of a book about psychic science. Mary's book talked about not only physical health but also mental health and called it science? Mary's book agreed there was such a thing as thought transference between people? This was going too far, Maurice thought!

Friends of his who also belonged to the Church of England blocked the publishing of Mary's book. It took fifteen long years before the book was finally printed. By that time Mary was no longer in Maurice's employ. His opposition could not stop her from publishing.

A Fair Exchange

Mary went to work as Secretary to James Hinton who had been an old friend of her father's. Hinton wrote about evolution and also about the art of thinking. It was the second subject that drew Mary to work with him.

Each had something to give the other. They studied the development of the mind. Mary taught Hinton mathematics and how to apply equations to the art of thinking.

The Magic of Numbers

It is possible, Mary believed, to express the basic notions of the universe in equations made of numbers and symbols. The number "1," for example, is the expression of unity in the universe. Zero is infinity. Anything could be translated into mathematical symbols: a rainbow, a butterfly chrysalis, a dust spiral. Mathematics gave power to discover truths in all fields of knowledge.

Mary wrote and talked about her beliefs with mystics from the East and psychologists from America. Founders of the progressive education movement in America studied her writings.

The Cranks

Mary had a group of friends who called themselves "the cranks." She met them at a vegetarian restaurant in London. After a time, they put out a magazine called "The Crank." Mary contributed many articles with catchy titles like "Are We Berserks or Christians?" Stuffy old Maurice couldn't stop her now!

For the next thirty years, books and articles poured out of Mary. Her titles show the wide range of her interests: "Mathematics in Occultism," "The Divining Rod," "The Schoolgirl Medium," "About Girls," "What One Might Say to a Schoolboy," "Hooliganism" (juvenile delinquency), *Philosophy and Fun of Algebra*, *The Logic of Love*.

For the twentieth-century reader, leafing through Mary's *Collected Writings* is a little like taking a trip with Alice through the looking glass: all sorts of odd ideas come skipping along, such as, "It is the moral duty of people not to go insane. Geniuses should live to be old rather than 'burning out' and dying young. Having secrets is a mistake."

Mary, for instance, made a rule for herself, when she was thirteen, never to keep secrets. That way she could publish whatever she wished and say whatever she chose.

Mary's daughters were grown up now and gone away, all except Lucy, who lived with her. Lucy was a chemist and she lectured at the London School of Medicine for Women. Her daughter, Alicia, was a mathematician of considerable talent who was said to have the ability to visualize figures in a fourth dimension. The youngest, Ethel, was a novelist.

Mary spoke at various clubs and societies, like the Parents' National Educational Union and the Christo-Theosophical Society. These meetings were open to all, and all shades of opinion were welcomed. They were attended by foreign scholars, ministers, editors, educators and other thinkers.

A Shocking Dream

Mary had grown up on religious sermons and found it hard to resist what she called "a little bit of preach." Yet she was always ready to deflate windbags or people she called "prigs." She may have been a bit of a prig but she didn't mind telling stories on herself.

For example, Mary had a dream which kept repeating itself. In the dream she went outside in a shocking condition.

She said, "I find myself . . . in the street without proper clothing, without bonnet and cloak, or even . . . my nightdress." (!)

When she had this dream, she always looked over the manuscripts which were waiting to be taken to the printer. She wanted to be certain that she had not revealed too much of herself in her writing. She did not want her "naked" feelings to show to the world.

World War I: The End of an Era

When World War I started, Mary's health was failing. She was sorry that she was too weak to knit sweaters and blankets for the war effort. Her contribution was to open her house to the many people who knew her.

"They came and found a quiet place for an hour, away from the turmoil of a country at war and the terrible news in the newspapers."

Mary was by now quite old. She had breathed life into wounded insects. She gave birth to five children--all living. She gave the power of thinking to students so they could find out what they needed to know to live well. She enlivened dry-as-dust mathematics classes for countless girls and boys. Now life was ebbing out of her.

Mary had been widowed for fifty years. She raised her family alone and now relatives as well as friends and even her own eyesight were slipping away.

"Ah me!" she wrote, "But it is a lonely world!" But she had a strong religious faith. And even sadness could be woven into a rich cloth--"If one knows the Artistic way of using the world's shadows . . . discords . . . and lurid dark silks. . . . "

Mary died at the age of 84. Her life spanned the Industrial Revolution in England. This period brought to England a new set of political and social challenges--public education, public health, trade unions, the cooperative movement.

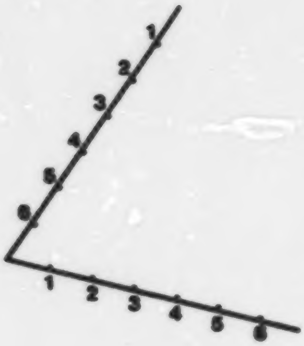
Mary called herself a mathematical psychologist. This meant she tried to understand how people (especially children) learned mathematics and science, using the reasoning parts of their minds, their physical bodies, and their unconscious processes.

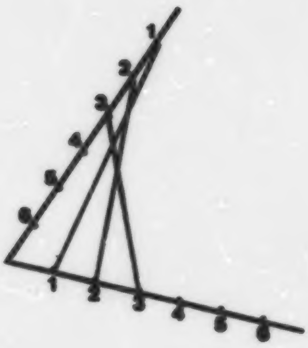
Her work influenced many others of her time: "Within the first decade of the present century," wrote her biographer, "new methods of teaching many subjects had been developed. Experimental work went on . . ."

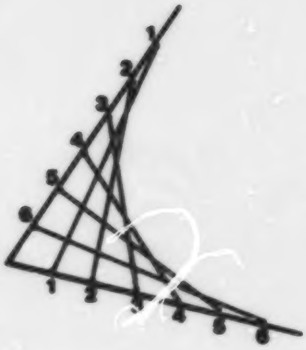
Today, in your own classroom, you may learn subjects the way Mary Boole taught them. Something may remind you of her ideas about how students learn, especially how they learn mathematics and science.

CURVE STITCHING

A nineteenth century mathematician and teacher, Mary Boole, developed a technique for making attractive designs by threading colored string through cardboard forms. Pictures of two of these cards, called **Boole Curve-Sewing Cards**, are included here. Curve stitching demonstrates an interesting mathematical idea. Curved lines can be formed solely by a series of straight lines. How can this amazing thing happen? Let's try it and see.

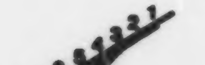


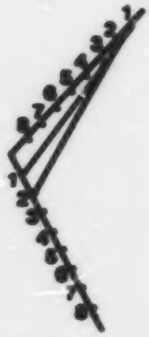


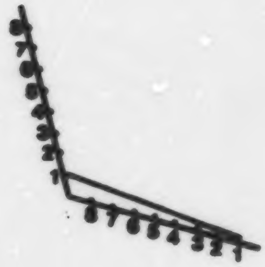


Notice the numbers drawn on both rays of the angles above. Draw a line connecting point 1 to point 1, another from point 2 to point 2, a third from point 3 to point 3. Keep doing this. Watch the trace of a curve appear as the lines are added.

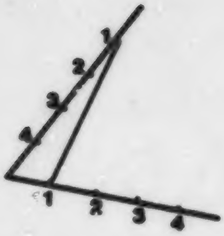
If the spacing between points is kept the same while the width of the angle is changed, the shape of the curve will change. Connect the points in the figures below and see what happens.

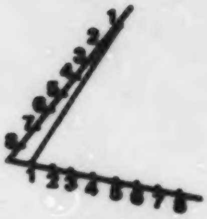






Notice what happens when the number of points on each edge is increased while the angle is kept the same.




1
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4
5
6
7
8
1
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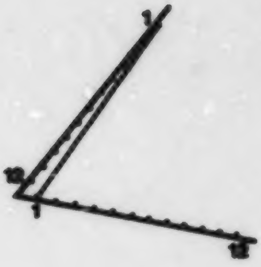
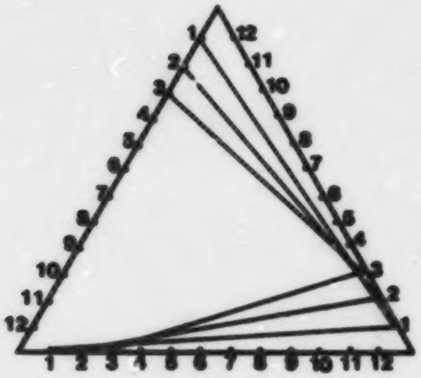
7
8



The more points, the smoother the curve!

Try connecting points on edges of other geometric figures. For example, try connecting the points on this triangle.


1
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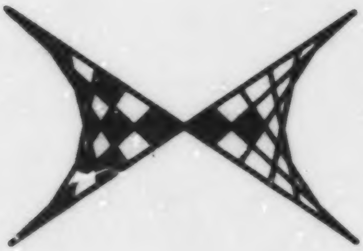
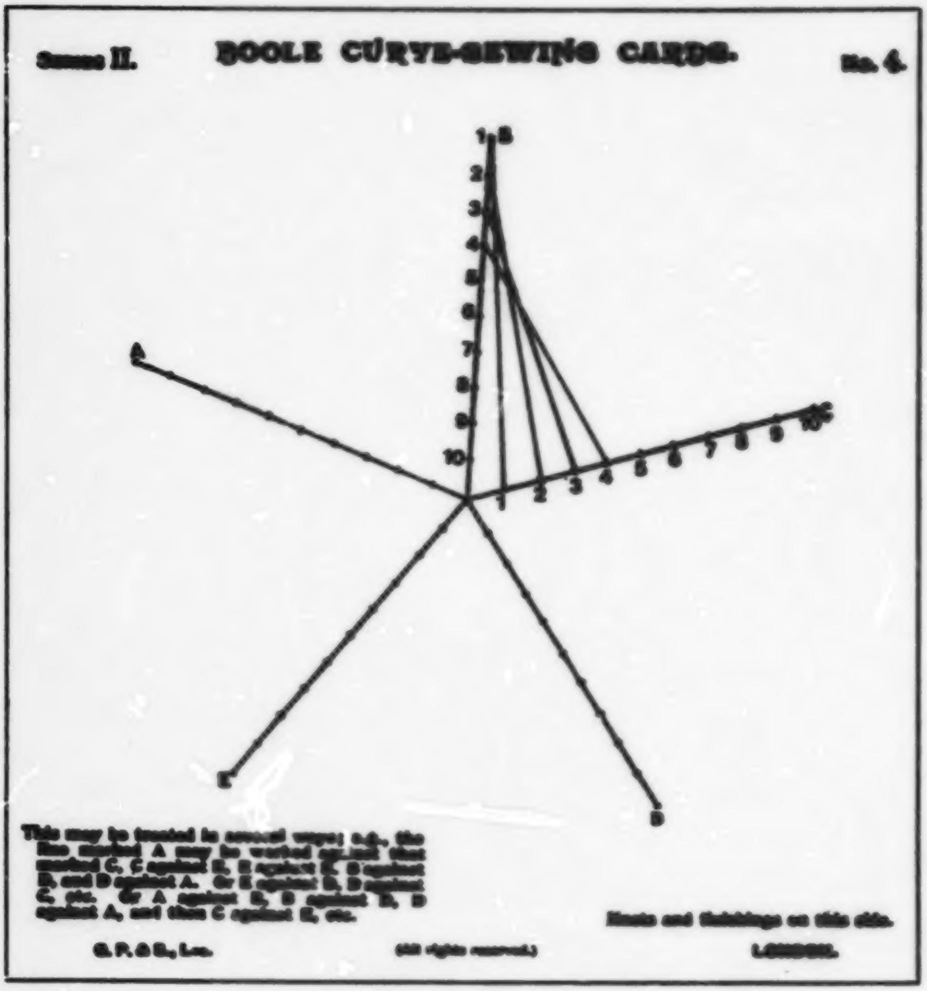
12

Experiment with other designs.

Make your own numbered shapes. Try coloring your designs like the illustration below. Many attractive designs can be made this way.



Here are pictures of two of Mary Boole's cards with numbers added in a few places. Connect the points in the usual way and watch the curved designs appear. Try connecting different edges. See how the designs change.


Series II.
BOOLE CURVE-SEWING CARDS.
No. 4.
1
2
3
4
5
6
7
8
9
10
B
A
C
D
E
1
2
3
4
5
6
7
8
9
10

This may be treated in several ways; e.g., the line marked A may be worked against that marked C, C against E, E against B, B against D, and D against A. Or E against B, B against C, etc. Or A against B, B against D, D against A, and then C against E, etc.

Knots and finishings on this side.

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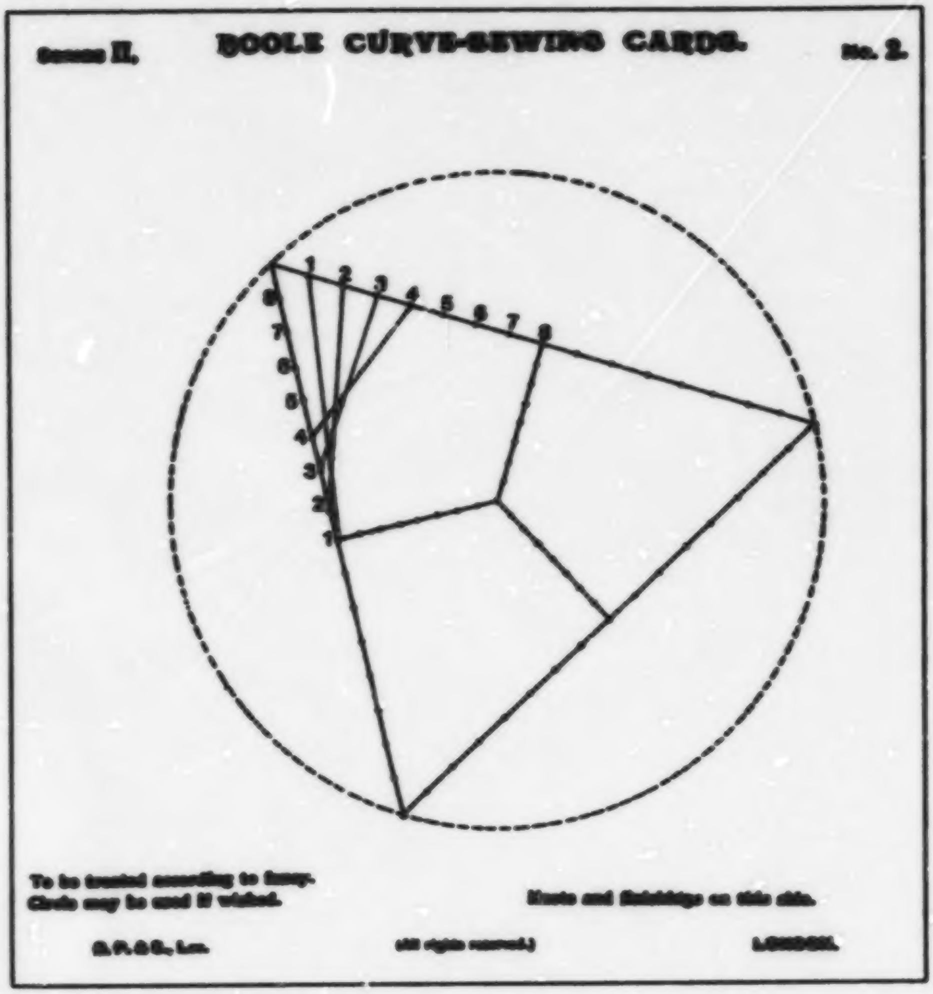

Series II. BOOLE CURVE-SEWING CARDS. No. 2.

To be treated according to fancy.
Circle may be used if wished.

Knots and finishings on this side.

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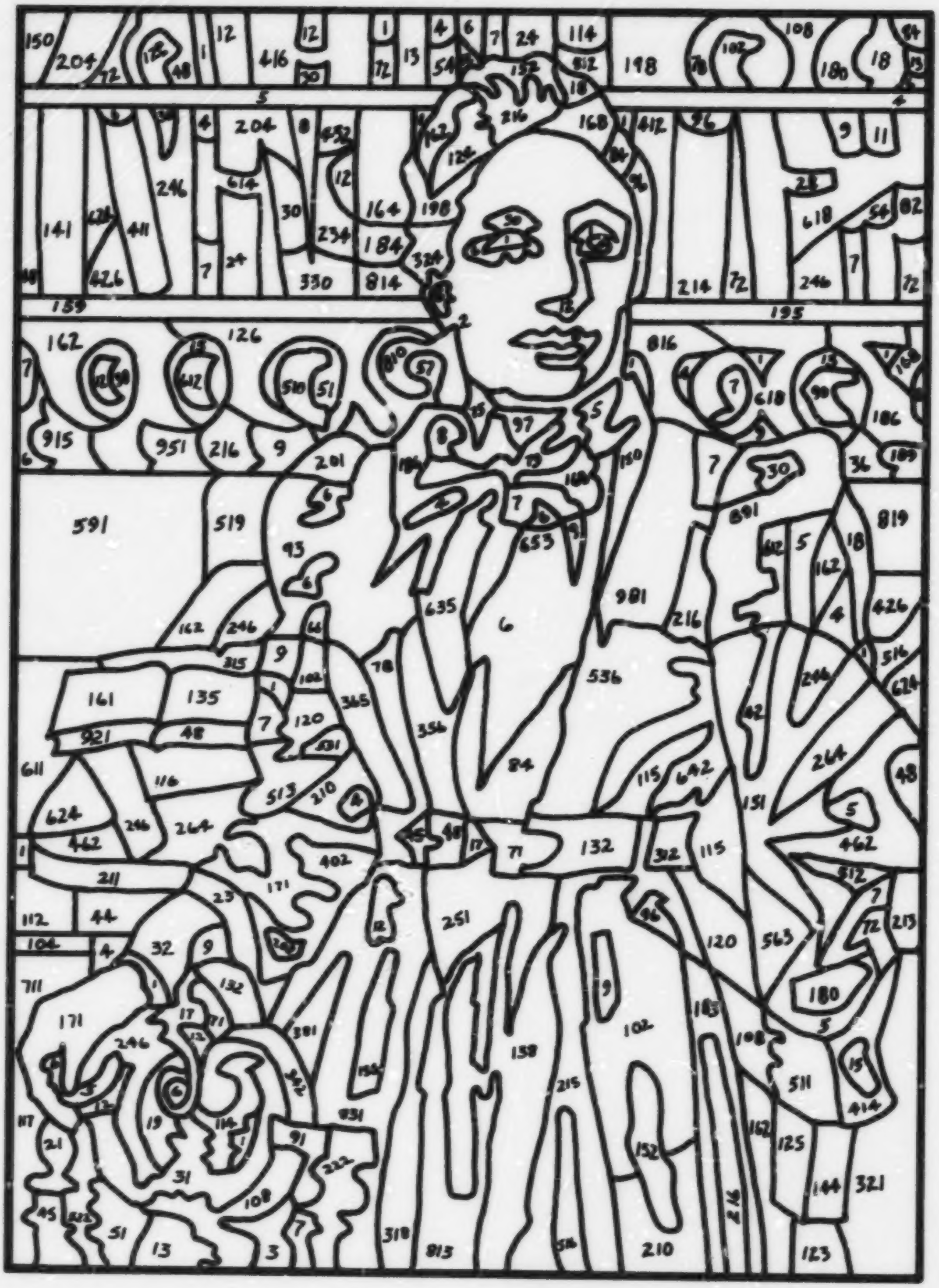
LINE DESIGNS by Dale Seymour, Linda Silvey and Joyce Snider is a book which suggests many more ideas you can try. (Creative Publications, P.O. Box 10328, Palo Alto, CA 94303)

SHADE ALL MULTIPLES OF 2 AND 3



EMMY NOETHER

1882-1935

An Ordinary Childhood

Emmy Noether was the greatest woman mathematician in the history of mathematics up to her time. Yet, when she was a young girl, no one would have predicted greatness for her.

Emmy was born in 1882, the oldest child in her family. She had three brothers, but two of them died at a young age. Her brother, Fritz, was two years younger than Emmy.

The Noether family lived in Erlangen, Germany. They were Jewish and, as part of their tradition, they honored learning.

Emmy's father, Max, was a mathematics professor and research scientist at the University of Erlangen. He was a kind, jolly sort of man. Her mother, whose name was Ida Amalie, was a typical "hausfrau" who kept a tidy, well-run household.

For her entire childhood, Emmy lived in the same apartment in Erlangen. She was very near-sighted and wore thick glasses. She learned the skills that were taught to girls of the middle class. She learned to play the clavier, which is something like the piano. She cooked and dusted. She liked going to family parties where there was dancing. Emmy loved to dance.

Her life might have been that of any ordinary housewife. But, just about that time, young women in Germany were admitted to universities to earn degrees. Now a career in science was open to her.

Emmy was friendly and cheerful. She also was clever. From the start, she liked languages and studied French and English. When she finished high school, she took a test and was certified to teach French and English in schools for girls. If she had to, she could now earn her living. Life was following the expected pattern for a young woman of her time and place.

But Emmy's was not an ordinary family. Not only was her father a mathematician, her brother Fritz was following in his footsteps. Fritz entered the University of Erlangen to study mathematics. Emmy was eighteen and began to sit in on classes at the University. She did this for two years.

She took the examinations for entrance as a doctoral student in mathematics and passed. Now she was a student in good standing.

Five years later, she received her doctoral degree. She was the second woman in the history of the University to receive a doctoral degree in mathematics. (The first woman received her degree the year before Emmy.)

A Degree But No Job

Emmy Noether was ready for her career. There was only one problem: no women were permitted to take jobs as mathematics professors in her city, or indeed, anywhere in Germany!

Emmy worked without pay at the Mathematics Institute in Erlangen. Partly, she helped her father in his work and partly she worked on her own research. Sometimes she taught in her father's place when he was sick. She worked this way for the next ten years--from 1909 to 1919. Slowly, her reputation grew. She began to publish papers about her work. In her lifetime she published forty-five papers.

The first world war began in 1914. Emmy was a pacifist. She had high hopes that this terrible war would end and there would be a lasting peace in Germany. In 1918, Germany lost the war. The German monarchy was overthrown, the country became a republic, and women were given the vote. But even though Emmy could vote, she still received no salary whatsoever for her job.

A Growing Reputation

Two great mathematicians, Felix Klein and David Hilbert, were working at the University of Gottingen in Germany. They heard of Emmy and thought she could help them in their work on Einstein's general theory of relativity. They invited her to move to Gottingen in the hope that she could join the faculty.

But there were no women on the Gottingen faculty. Other faculty members said, "What will our soldiers think when they return to the University and find they are expected to learn at the feet of a woman?" Most German women were housewives. Prejudice against women ran high if they tried to become anything else.

Throughout these arguments between Hilbert and the rest of the faculty at Gottingen Emmy remained serene. She did not become bitter. She thought people were good, and kept that belief uppermost in her mind.

Emmy was now thirty-seven years old, and her reputation as a brilliant mathematician was growing fast. Finally, she received a place as a lecturer at the University of Gottingen. Instead of teaching for other professors, she could now teach courses under her own name. Three years after this, she finally received a small salary. This was timely because Germany's post-war economy was wracked by inflation, and money from her family's estate, which had helped to support her, petered out.

The Noether Boys

Emmy gathered a group of students around her at Gottingen. Her growing success as a mathematician attracted outstanding students. They came from Russia, the Netherlands, and other countries. They made a lively group--these "Noether Boys." (Years later, when Emmy taught at a women's college in the United States, her group was known as the "Noether Girls.")

Emmy's style of teaching was confusing. Her explanations were, as her student Van der Weyden put it, "rattled off at top speed." She would launch into these explanations, feverishly writing symbols on the board, leaving unfinished sentences in her wake, and a group of puzzled students sitting in front of her. Perhaps, being so near-sighted, she never noticed their puzzled expressions.

Once, after she had given a lecture to a large group of students--some regular students and some visitors--one passed a note up to her. It read, "The visitors have understood the lecture just as well as any of the regular students." (Or as badly!)

But not all of her students lacked understanding. A few, who were patient and attentive, caught on and became loyal followers. They learned to snatch the ideas she flung out, and put them to use in their own research. In this way, they advanced and became distinguished mathematicians in their own right. They never forgot their debt to Emmy Noether, and some gave her credit in their own works.

68

One of her former students, Alexandroff, invited her to Russia to the University of Moscow. He later wrote about her visit: "Emmy Noether very easily fit herself in with our life . . . she lived in a modest room in the KSU hostel near the Crimean Bridge, and most of the time she walked to the University. She was very much interested in the life of our country, especially in the life of Soviet young people. . ."

All during the twenties, Emmy's work in algebra progressed. Her work was part of the new algebra. Her work did not rely on adding or multiplying numbers or solving equations. Instead, her work in algebra dealt with ideas.

A Brilliant Mind, A Warm Personality

Emmy never hoarded her brilliant ideas like a miser. She was generous with her genius. Her students were like her own family. She was interested in their personal lives, and listened to their problems. She was "warm, like a loaf of bread," said Herman Weyl, one of her biographers.

Emmy had a deep voice, like a man's, and it was loud too. She laughed heartily. Though she was not tall, she was heavy-set. She looked solid, earth-bound. Yet her ideas soared with ease and grace, as did her lively spirit.

Departing the Homeland

In 1833, the Nazis, who had come to power in Germany with Hitler at their head, demanded that Jews be thrown out of all university positions. Emmy's brother, Fritz, had to move with his family to Siberia, where he was offered a position at the University of Tomsk. Emmy too had to leave Gottingen, and the beloved country of her birth. One of her Russian students, and a good friend, Alexandroff, desperately tried to secure a place for her at the University of Moscow. But before he could do this, American friends found her a job as visiting professor at Bryn Mawr, a women's college near Philadelphia. Here, Emmy moved in 1933, when she was fifty-one years old.

A Woman Mathematician In America

Besides teaching and doing research at Bryn Mawr College, she gave weekly lectures at the nearby Institute for Advanced Study in Princeton, New Jersey, where Albert Einstein and other famous German refugees now worked.

As a professor at Bryn Mawr, Emmy Noether made quite an impression. A woman who was a student at Bryn Mawr at that time, Betty Morrow Bacon, recalls meeting Emmy soon after her arrival in America.

"Before she came we were told, 'This is one of the great people alive in the world today. It is an honor to have her at Bryn Mawr.'

"When I first saw her striding across the campus, I felt a little scared. Her expression seemed stern and forbidding. She was large and solid-looking and she wore a long dress. She didn't speak. She was not at all like other people I knew.

"There was a faraway look on her face, as though her mind was not in this world at all. What was she thinking of? Maybe she missed her old life in Germany. Maybe higher mathematics filled her thoughts. I never knew. . ."

Another student at Bryn Mawr, a graduate student in mathematics, Grace Shover Quinn, recalls her impressions of Emmy after she was settled into her new life at Bryn Mawr.

Emmy Noether . . . "was around five feet four inches tall and slightly rotund in build . . . she had a way of turning her head aside and looking into the distance when trying to think while talking. . . Her lectures were delivered in broken English. She often lapsed into her native German when she was bothered by some idea in lecturing . . .

"She loved to walk. She would take her students off for a jaunt on a Saturday afternoon. On these trips she would become so absorbed in her conversation on mathematics that she would forget about the traffic and her students would need to protect her."

Anna Pell Wheeler was Head of the Mathematics Department at Bryn Mawr. Professor Wheeler had studied at the University of Gottingen and understood the German life style. She could appreciate how Emmy's career was blocked in Germany because of her sex. She could understand the shock of being uprooted from the German culture, and transplanted to another world.

This was the first time Emmy had a department head who was both a mathematician and a woman. Up to this time, all her colleagues were men. When Emmy's old friends and former students came to Bryn Mawr to visit her, she introduced Professor Wheeler as her good friend.

Death: A Great Shock

In 1935, Emmy Noether entered the hospital to have an operation. She was getting well at the hospital when, suddenly, complications set in. Within hours she was dead--a great shock to her unsuspecting friends all over the world.

Emmy did not write about herself. Unlike her great mathematics ancestor, Sonya Kovalevskaya, she wrote no autobiography. But others talked of her and they remembered her.

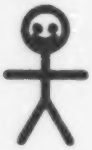
Soon after her death her Russian friend, Alexandroff, gave a talk to the Moscow Mathematical Society. He said, "Emmy Noether . . . was the greatest of women mathematicians, a great scientist, an amazing teacher, and an unforgettable person . . ."

ABSTRACT ALGEBRA

Emmy Noether worked in a part of mathematics that is called **abstract algebra.** This kind of algebra is quite different from the algebra you learn in school.

In abstract algebra people talk about GROUPS and RINGS and FIELDS. **Fields** are more complicated than **rings**, and **rings** are more complicated than **groups**. Believe it or not, the simplest arithmetic you learn in school is far more complicated than many examples of **groups** or **fields** or **rings**.

If you don't believe this, try these examples.



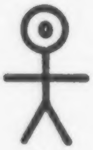
Meet Sticky

Imagine a stick figure that can move only its two arms . . . and these two arms can move only up or down.

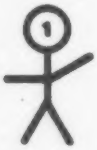
Suppose we want to describe the motions Sticky can do. If we do so in a certain way, we can turn Sticky and Sticky's motions into a full-fledged mathematical animal called a group.

Let's think about the four possible ways that Sticky can move. Let's label these four ways 0, 1, 2, and 3.

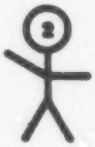
This is MOTION⓪.
Here Sticky does not move at all.



This is MOTION①.
Here Sticky **moves right arm once.***



This is MOTION②.
Here Sticky **moves left arm once.**



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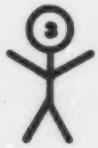
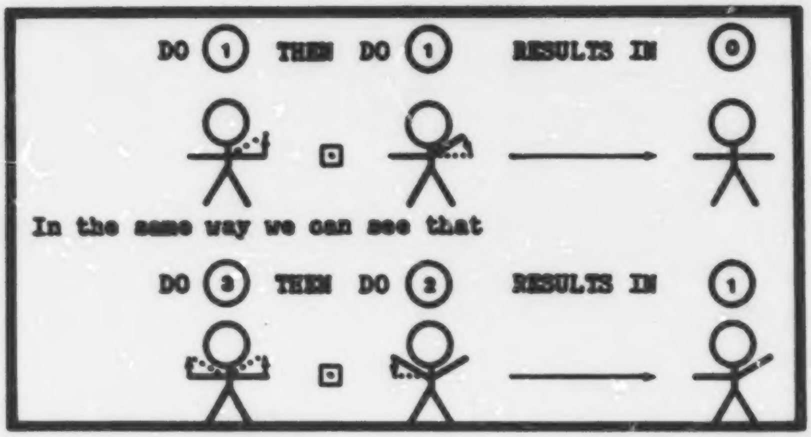
* By "move once" we mean, if arm(s) is straight out it moves UP. If arm(s) is UP, it moves STRAIGHT OUT.

This is MOTION 3.
Here Sticky moves both arms once.



If Sticky moves right arm twice, Sticky will be back in first position.
So we can write an EQUATION.

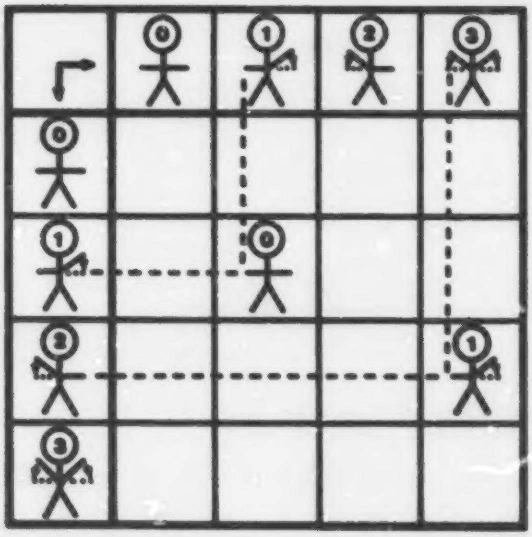
Just as we have learned in ordinary arithmetic that 3+3=6, we can say here:


DO ① THEN DO ① RESULTS IN ⓪

In the same way we can see that

DO ③ THEN DO ② RESULTS IN ①

See if you can fill in the table below. For each square first do the motion that the figure at the top is doing; then do the motion that the figure at the side is doing.



How do you end up?

That's the answer. Put this answer in the appropriate square.

Do you see that the figures in the squares make a pattern?

CLOCK ARITHMETIC

Another example of a **group** is the special arithmetic called **clock arithmetic.**

- Think about the face of a round old-fashioned clock.
- How many numbers do you see on it?

Suppose it is 10:00. You tell your friend you will be back in 3 hours. What time will you be back? Right you are. You will be back at 1:00.

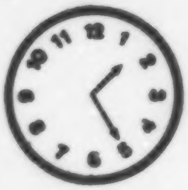
You can write a funny-looking arithmetic sentence . . . $10 \oplus 3 = 1$

Notice the circle around the +. That tells those who know, that we're doing **addition** around a circle. This is the special **clock arithmetic.** Look at the clock and finish the following sentences.

$5 \oplus 8 =$ ________

$8 \oplus 5 =$ ________

$11 \oplus 4 =$ ________



In ordinary arithmetic $3 + 2 = 5$

$1 + 4 = 5$

$2 + 3 = 5$

$4 + 1 = 5$

$0 + 5 = 5$

$5 + 0 = 5$

These are all the different ways you can make 5 by adding just two whole numbers.

How about **clock arithmetic?**

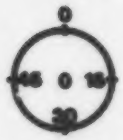
In **clock arithmetic,** how many ways can you make 5?

You can say that $11 \oplus 6 = 5$

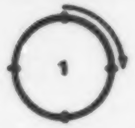
$10 \oplus 7 = 5$

I'm sure you can think of many other ways.

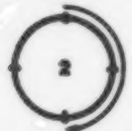
Now let us consider a very simple example of clock arithmetic and its solution in the square at the bottom of the page. This clock has only 4 positions that matter. We can think of these as follow:



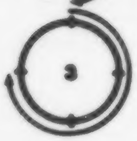
0 means stay where you are.



1 means move head 15 minutes.



2 means move ahead 30 minutes.



3 means move ahead 45 minutes.

Now do the additions as you did before, and complete the squares.

- Remember, 1 + 1 = 2 means move one step clockwise. Then move one more step clockwise, and you've arrived at position 2.

How about a 2 + 2 = _________?

- Notice the pattern of numbers when you've completed the square.

+	0	1	2	3
0				
1				
2				
3				

- Compare the difference in the patterns of the clock square and the Sticky square.

The pattern in each square comes out of exactly 4 numbers (or elements) and a rule for combining them.

- Why are the solution patterns different for these two squares?

Emmy Noether's work gave mathematicians new tools to solve old problems. In particular, she developed important new ways of classifying these kinds of situations in rings, the next more complicated structure after groups.

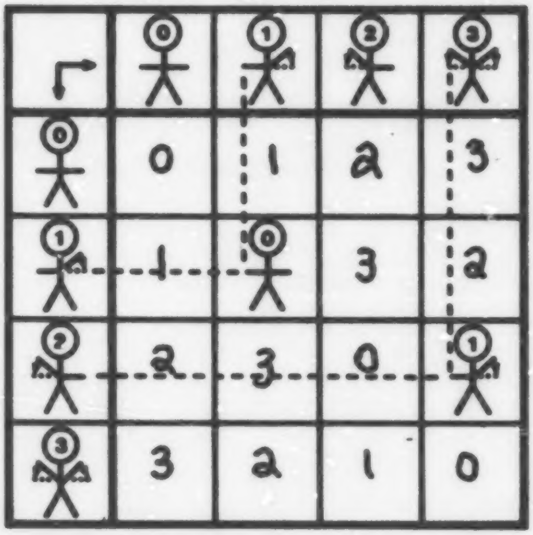
COMMON MULTIPLES OF 2 AND 3

- All numbers that are common multiples of 2 and 3 are numbers that are multiples of 2 as well as multiples of 3.
- All multiples of 2 are even numbers. Therefore common multiples of 2 and 3 are even multiples of 3.
- See page 95 for details on "multiples of 3" test.

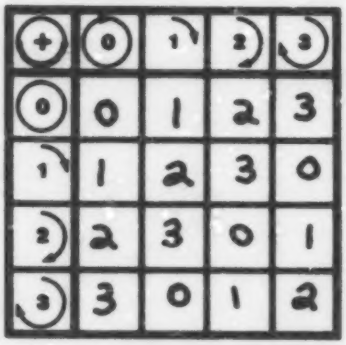
Using common multiples of 2 and 3, shade in Emmy Noether's picture on page 68

SOLUTIONS:

- Notice that for both squares, each number appears only once per row and column.
- If you were to fold the large square along the northwest/southeast diagonal, each half would match. This diagonal is a line of mirror symmetry.
- Notice how the number patterns differ for each square.



↱	⓪	①	②	③
⓪	0	1	2	3
①	1	⓪	3	2
②	2	3	0	①
③	3	2	1	0



⊕	⓪	1	2	3
⓪	0	1	2	3
1	1	2	3	0
2	2	3	0	1
3	3	0	1	2

LENORE BLUM

BEST COPY AVAILABLE

LENORE BLUM

1944-

A Tropical Paradise

The airplane carrying the two girls descended, and the city of Caracas, Venezuela, rose up to meet them. It was the dry season and fires in the mountains caught their eye. They saw small aircraft dropping chemicals to put out the flames. As they approached the airfield, the sun illuminated a landscape of palm trees and flowers, modern buildings and streets. To Lenore, the older one, this was paradise, and it was her new home!

Lenore and her sister had left their home in New York. The whole family was coming to live in South America. Here, Lenore's father hoped to make a good living in the import-export business.

The drive from the Caracas airport to their new home was full of strange sights. An attempted revolution was taking place. Opposition forces, who wanted to overthrow the dictator, had thrown tacks in the streets to puncture tires and disrupt the city. Christmas trees were tied to front fenders of cars to sweep away the tacks.

Their lodgings were wonderful--several rooms rented in a large house. Views from second-story windows showed the lush mountains. For the first time in her life she had a back yard. Unknown in New York! In the yard, a parrot squawked--gorgeous, brilliant-hued, tropical.

Lenore was nine and her sister, Harriet, was seven. They were going to attend the local school where only Spanish was spoken and no "foreigners" were enrolled. This would be quite a change for Lenore. Most of her friends had been American in the old school. Many were Jewish as she was; in fact, in New York she had hardly known anyone who was not Jewish.

65th Avenue, Queens

Home in New York had been an apartment on 65th Avenue in Queens. Her earliest memory was standing at the window watching her father, Irving, when he arrived home after World War II. From the candy store on the corner, she bought a Yiddish newspaper, "The Forward," for her grandmother, who lived with the family. Her grandmother spoke only Yiddish. Lenore understood Yiddish, and although she didn't speak it herself, she translated her grandmother's words into English when people came to visit.

When she was young, relatives commented to each other, "How artistic Lenore is!" Art was her favorite activity, though she usually didn't show her projects to others. One time she used an orange as a base and built a hand puppet from papier mache, using strips of newspaper and paint. The puppet had blond hair made from wool yarn. It was different from anything that could be bought in the stores. It had "personality."

Lenore visited libraries and museums with relatives and even by herself. She loved the dinosaurs at the Museum of Natural History and the wild animal habitats. Sometimes she traveled by subway to the New York Public Library and the great museums in Manhattan--the Metropolitan Museum of Art and the Museum of Modern Art. They filled her with wonder.

Her cousins, Ellen and Shelley, lived in her neighborhood and they, Harriet and she played together. This was in the early days of television and on one program, called "The Magic Cottage," children applied through the mail to be on the show and win prizes. All four girls eagerly applied. Shelley and Harriet were chosen. Ellen and Lenore talked and persuaded, persuaded and talked until the other two gave in. Ellen and Lenore appeared on the show.

Many of the prizes were of some value, such as a child's record player. But Lenore saw just what she wanted: a puppet which folded up into its own little case!

"Why didn't you pick the record player? It's much more valuable," the grownups wanted to know. Valuable? To the others, maybe, but not to Lenore.

Growing Up

The women in Lenore's family were very proud of their professions and she grew up with the idea that a profession was a very important thing for a woman to have. Rose, Lenore's mother, taught science in a New York high school. At one time she had studied to become a doctor. Rose's sisters often came to the house to visit Lenore's grandmother. Two of these women were lawyers and a third was a teacher.

They often spoke of their older brother, Sol, who had become a medical doctor. Though he had died at the age of 32, his presence was strongly felt. As the oldest child of an immigrant family, he had led the way.

Every now and then Lenore would take from the hall closet a violin that belonged to her Uncle Sol. She was like this uncle; she would do something special. It didn't really matter to her that later, when she took violin lessons, she showed no talent for the instrument. What mattered was that she felt there was a tradition of scholarship for her to follow.

Lenore went to a progressive school which didn't give grades. She loved school and loved the summers at Far Rockaway beach where she played with her sister and her cousins. She used New York, the largest American city, as her playground. She had plenty of free time. No one kept close track of her. This suited her perfectly.

There was one flaw, a fear that came and went: her beloved grandma might become ill when no one else was there. But the years of her childhood passed and her fear was never realized. Suddenly, she was moving away to South America.

South American Scenes

Caracas, Venezuela, in South America, was another link in the golden chain of events in the child's life. Lenore's first glimpse of the city confirmed her belief that good things would always happen to her.

The first day of school shattered the perfect picture. The boys in the class had learned a few words of English from American movies. "I love you," they whispered as they ran around the two American girls. How humiliating!

Then there was the principal. Here were two young American "ninas" who "no hablan Espanol." But they must learn to speak Spanish--pronto! The principal would teach them one hour each day in his office, beginning with the subjunctive tense of the verb.

Disaster! Lenore hadn't learned grammar even in her native English.

A further humiliation: school officials put Lenore back a grade so that her age would match her classmates. In the classroom the teacher, Senorita Candelaria, used a method of teaching that was altogether strange to Lenore. The students were given blue "cuadernos" or notebooks. They had to copy stories and pictures into their notebooks over and over until they matched those in their textbooks. Every cuaderno in Lenore's class looked exactly alike!

Meanwhile, right outside the windows, lay a city which at that time was one of the most beautiful in the world. Such a bright world, too, after sunless days in New York.

Two weeks was all Lenore lasted. "I quit!" she announced to her parents. And that went for her sister, too.

A Year of Freedom

Lenore's mother was a veteran teacher. School, in any country, held no secrets for her. Far better, from her point of view, to educate her daughters by exploring this brand new place than to leave them in the local school.

So the decision was made. For one year, Lenore, going on ten years old, and her sister, seven, did not go to school at all. Instead, they traveled on buses each day with their mother. They took in all the sights of the city. No formal lessons now, only informal ones that the city and its inhabitants had to teach. At the end of the day they went to the cafe where the "foreigners" met. The girls ordered ice cream sodas. Life became much easier for Lenore.

Homesickness

But another feeling crept in--homesickness. Lenore expressed it by writing a poem. It spoke about all the things she had left behind, about Thanksgiving, about her grandma. It was filled with longing. Her poem won a prize and was published in the English language newspaper, the "Caracas Daily Journal."

She also made a pencil sketch of her grandmother. The background for the sketch was engraved in Lenore's memory: the comfortable cushioned chair her grandmother had sat in, the gooseneck lamp so the elderly woman could sew and read the newspaper, the wall paper with its pink and rose flowers, the photograph of her grandmother's parents--

Russian peasants in kerchief and cap--mounted on the wall, the piano bench on one side of the chair and the little table for her sewing on the other.

But try as she might, Lenore couldn't get her grandmother's face right, not the way it really was. She left the sketch unfinished.

A new year started. A decision would have to be made about the girls' education. Seventy thousand Americans lived in Venezuela. They were oil company employees and their families. Many were wealthy and they had their own schools. The one in Caracas was called Escuela Campo Alegre.

Escuela Campo Alegre--The American School

Lenore's family could not afford the tuition at this school so Lenore's mother went back to work, teaching at the American school. Lenore and Harriet began classes there.

In mathematics, long division was being taught. The teacher gave an explanation. Lenore understood instantly. In fact, she understood all the new work. Though she had fallen behind because of the year's absence, she caught up and moved to the top of her class. From then on, until she graduated from high school at the age of sixteen, Lenore was the top student and mathematics was her favorite subject. Although she was a girl and the best student in mathematics, the others did not look down on her. They simply thought she was "different." Lenore made plenty of friends.

An Impression

Her family met another Jewish family in Caracas. There were four sons in the family. The oldest, whose name was Manuel, was serious and a little shy. From their first meeting Lenore made room in her heart for this boy. He was like her; they were simpatico. He was the one she would one day marry.

Lenore rarely saw Manuel in the next few years. He was four years older than she and soon went off to the States to study at the Massachusetts Institute of Technology (MIT). But he had made an impression.

Los Pavos

Like many teenagers, Lenore had many images of how she wanted to be. She was trying out a variety of roles and sometimes her actions seemed contradictory, even to herself.

When she was in high school, her friends were "los pavos," which was Caracas slang meaning the fast crowd. One day, while she was riding with a boyfriend on his motorcycle, they had an accident and crashed. Lenore fell on her head. She felt the wound where blood was clotting.

"My brains! My brains are spilling out!" thought the panicky thirteen-year-old. But, with only a head patch and two weeks' time, she was well again. Then and there she decided that motorcycles were not worth the risk.

Cars, clothes, bikes and romances were part of the American school scene. Money was thrown around and parties were frequent. Lenore's parents were tolerant. To them, she was the older daughter, the little girl who had taken care of her grandmother so faithfully. They set no limits, so Lenore set her own: a 1:30 curfew, and she never came home later.

A Coup

When Lenore first arrived in Caracas, an attempted revolution was taking place. Five years later, on New Years Day in 1958, the dictator, Colonel Marcos Perez Jimenez, was finally overthrown. The citizens of Caracas were jubilant. The hated secret police fled and ordinary people ran the country. Boy Scouts directed traffic and university students helped maintain order. Sometimes students who were friends of Lenore's took her with them on their patrols after the curfew fell at night. She loved being part of the excitement. The controlling junta--the new ruling group--promised elections in the fall. Every five years thereafter, free elections have taken place in Venezuela.

Searching for a Profession

Mathematics was Lenore's favorite subject. Instruction in mathematics at the high school Lenore attended was poor, and so she learned a whole year of mathematics on her own. When she expressed an interest in going on with mathematics in college, her teacher advised against it.

"Everything important was discovered 2000 years ago," he told her. "You don't want to go into a dead field."

Was that true? The sixteen-year-old transplanted New Yorker did not know. All she knew was when she looked at a proof on the board, her heart swelled. "It's so beautiful, so perfect." Mathematics cared for no one's opinion. Mathematics was, that was all.

Buildings, beautiful modern concrete forms were springing up all over the city of Caracas. Architecture was exciting, creative. Here was a career field that combined her two loves--mathematics and art. That is what her college major would be.

But where to apply? To MIT, of course, where Manuel was and where so much exciting work was being done.

To Lenore, MIT was the pinnacle, but, to her great dismay, she was not admitted. In response to her application, MIT officials said, "We have only twenty beds in the girls' dormitories and incoming students must live on campus." Only very few women were accepted. [This excuse of dormitory space was corrected some years later. One of the first women to graduate from MIT, Katharine McCormick, gave a large sum of money to be used solely to build a dormitory for women students.] Lenore decided to go to Carnegie Institute of Technology in Pittsburgh, Pennsylvania, instead.

Graduation Summer

Lenore was valedictorian of her high school graduating class. Manuel came to Caracas for the ceremony, and her senior prom was their first date. That summer, the two young people talked about many things: Freud and modern psychology, philosophy, and the make-up of the brain. A neuron could be expressed mathematically. Fascinating! More than ever now, she looked forward to college.

From Caracas to Pittsburgh

Pittsburgh was an industrial town, a maker of steel--old and dingy. Quite the opposite of sparkling Caracas. The students of architecture at Carnegie Tech were very serious about their career goals. They worked together in a room that took up an entire floor of a building. Often they worked through the night to finish projects. Older students offered criticism and advice. Everyone was helpful and friendly.

Mathematics is an important tool for architects and they were interested in learning formulas. Lenore, on the other hand, was interested in learning where these formulas came from and why. She missed the beauty of mathematics.

In her second year at Carnegie Tech, Lenore changed her major from architecture to mathematics. She knew immediately that she had made the right choice.

Marriage and MIT

Lenore was now eighteen years old and she and Manuel married. They moved to Boston and rented a small apartment. The young couple's home was open to a growing circle of friends.

Manuel worked in Warren McCulloch's Neuro-Physiology Lab at MIT. Here people from all over the world--from Australia, England, Israel, Holland, Italy--came to work. These people were electrical engineers, mathematicians, philosophers, biologists, psychologists. They came together to work on a common problem--the understanding of the brain.

Lenore's and Manuel's apartment became a gathering place for the young people in the evenings. Eating, singing and playing drums in the small living room gave way to lively debates. One might recite a jazzed-up version of "Jabberwocky," a poem by Lewis Carroll. A poem by William Blake could start a discussion about infinity (and other mysterious ideas) that would last through the night.

"To see a World in a grain of sand,
And a Heaven in a wildflower,
Hold Infinity in the palm of your hand,
And Eternity in an hour."

"Auguries of Innocence,"
first stanza, by William Blake.

Continuing College

Since she was now living in Boston, Lenore applied and was accepted at Simmons, a women's college. She hadn't the courage to apply again to MIT.

Mathematics classes at Simmons were not sophisticated enough. The college administrators agreed to send Lenore to MIT to take a course in modern algebra. The teacher was Isadore Singer.

"Here was a class with substance, depth, pace--everything I'd imagined a good course to be. It was hard, it was deep, it was abstract . . . I trusted this guy who was teaching it. He was a top mathematical researcher. The topics were important; they were leading somewhere. He wasn't just reading it out of a book." Lenore was transformed!

She was very quiet in class. She didn't know where she stood. She was just grateful to be there. The class was huge, nearly 100 students. Lenore finished the semester as one of the top students. Yet, when she applied to the graduate program in the Mathematics Department, she was told by the admissions officer, "MIT is no place for women. Here is a list of fine graduate schools. Apply to these," the man told her. "I would give my own daughters the same advice."

Lenore felt devastated. It looked as though she would again be turned down by the only place she wanted to go, a place where exciting mathematics was happening.

That weekend, there was a party at MIT and Professor Singer was there. He overheard a group of people discussing "the girl who wants to enroll in the graduate mathematics program."

"Who was she?" Singer wondered. It was Lenore Blum. Professor Singer spoke up: she was one of his best students.

Within a few days Lenore received a letter of acceptance from MIT. (Times have changed. Today, MIT brochures state, "MIT is a place for women.")

Graduate School

Lenore decided she would start off graduate school with a bang. Most people took two or three courses each semester. Lenore would take eight. It was said that if a woman married she would not finish the program. Lenore was married and she would finish. It was said that a woman with a baby would drop out. Lenore would have a baby and remain. In spite of everything she would continue.

At first, life was difficult. Eight courses were more than anyone could handle. Lenore dropped them one by one.

Manuel had his group but she was on her own. Her co-workers were not used to working with a woman equal. Some even tried to drive a wedge between her and Manuel, for reasons Lenore couldn't fathom.

There were two other women in her class, both married and both with babies. But even though they had surely met similar obstacles, there was no feeling of being involved in a common struggle.

Nevertheless, later on in the program, an older woman student spent a lot of time helping Lenore prepare for the crucial oral examinations. Lenore began to realize how women could help women.

A Fantastic Baby

She and Manuel had planned the arrival of their baby to coincide with the end of the school year. They took natural childbirth classes, which were quite unusual at the time, and on the last day of classes, went directly from MIT to the hospital to have the baby.

Lenore nursed her new baby, whose name was Avrim. He was " . . . so fantastic. We really had a lot of love for him right from the start." She was very happy.

Lenore, Manuel and Baby Avrim were always on the go. The new parents eagerly tried out the newest in baby gear such as paper diapers, infant seats and porta-cribs.

Child care centers were very rare. Babysitters were hard to come by. Fortunately, Manuel had an office in the basement at MIT and they cared for the baby there.

Working on a Thesis: Logic and Algebra

Lenore went on with her work. She did not wait for an advisor to set her to work on a topic. She found her own topic which became her thesis.

Some mathematicians were successfully using new methods of logic to solve old problems in algebra. What an intriguing idea! Lenore taught herself logic and carefully studied these methods and how they were applied. She wanted to understand why they worked. She thought and thought about this from many different angles.

But what to do with Avrim? He was now a toddler and needed a lot of attention. Fortunately, during this period, Lenore's mother was able to come to Boston to help care for him.

MIT had set aside a group of rooms especially for women students. This is where Lenore would work. The rooms were located right under the famous MIT dome in the main building. Here she made herself at home. She brought her papers and books and set up her working space.

Lenore became engrossed in study and thought. Sometimes she worked through the night. She bought food from the vending machines in the basement and slept in the lounge. Day turned into night. She lost track of time.

Slowly patterns started to emerge. Lenore began to see common features in the problems she was studying. She realized that one simple but powerful rule could solve them all. She understood this rule so well that she could explain it to the logic group in the mathematics department and show them why it worked.

This rule and its proof became her first theorem. Later she used this rule to discover new results in algebra herself. This work was to become her thesis, but first she needed an advisor.

A logic professor, Gerald Sacks, had recently come to MIT and was enthusiastic about Lenore's work. He was the natural choice. She became part of the logic group and was included in all their discussions and talks. Now she really belonged!

People who were respected in her field came to hear about her work when she defended her thesis. The work she did earned her the doctoral degree. She received a post-doctoral fellowship and could go to work any place she chose for one year.

Berkeley was the obvious place to go. The mathematics department was one of the best in the country. A famous logician, Julia Robinson, lived there, and Manuel had a job offer, there as well. [Julia Robinson was the first woman appointed Professor in the Berkeley Mathematics Department, the first woman elected to the Natonal Academy of Sciences, and the first woman president of the American Mathematical Society.]

Berkeley, California

Politics was part of the Berkeley scene. It was 1968. People marched in the streets. They demonstrated against the war in Vietnam. They gathered to protest turning a park into a parking lot. They talked and they organized. Out of the Free Speech Movement came a new spirit. It was an exciting time.

Bright blue skies and Spanish tile roofs nestling in green hills reminded her of Caracas. People wore colorful, free-flowing clothing. Lenore felt she was coming home.

During her post-doctoral year at Berkeley, Lenore received several job offers. People at Yale were eager to work with her and offered her a position as assistant professor. She had offers from MIT and from Berkeley. Manuel had a job at Berkeley and so Lenore took the Berkeley offer, even though it was the lowest rank. The position was lecturer in mathematics.

These were important things to consider but Lenore did not realize this at the time. Although discussions with her employers raised her hopes, no tenure or job security went with the position. What was worse, she had no professional group at Berkeley to support her career growth.

A Turn of Events

After two years as lecturer at Berkeley, Lenore was told she would not be re-hired. People assumed she would become another faculty wife. Lenore's talent and training prepared her to work at the highest level. But there were no women in positions at that level at any of the top mathematics departments in the country. What to do?

About this time three concerned professors in the Berkeley Mathematics Department [Moe Hirsch, John Rhodes, and Steve Smale] sponsored a series of talks on mathematics and social responsibility. Lenore was asked to organize a panel on women and mathematics. She gathered together scholars [Ravenna Helson, Sheila Johannsen, and Elizabeth Scott] who spoke about the history of women in mathematics and their present status. Several hundred people packed the lecture hall; this was the first such panel anywhere in the country. All of a sudden, Lenore became known as the expert on women and mathematics on the West Coast.

On the East Coast, women mathematicians had also begun to organize. That winter Mary Gray, of American University, led a protest at the mathematics meetings in Atlantic City. She wanted women to be part of the decision-making groups in the mathematics societies. During the spring, Mary issued a Newsletter and called for support. The Association for Women in Mathematics (AWM) had begun.

At first, Lenore was reluctant to join. She wanted to be known as a mathematician, not as a *woman* mathematician. But soon she became convinced: the situation for women in mathematics would not change without the AWM. [Mary Gray was the first president of the AWM and Alice Schafer of Wellesley College the second. Later, Lenore became president. Other presidents have been Judy Roitman of the University of Kansas, and Bhama Srinivasan of the University of Illinois at Chicago Circle.]

The AWM and Change

It was 1971 and the beginning of a new era for Lenore and other women mathematicians. They spoke out. They wrote letters. They sponsored talks and panels and debates. In their newsletter, they pointed out how it was harder, sometimes impossible, for women mathematicians to get good jobs. They asked tough questions and they were not always popular. But they gained courage and support from one another.

For the first time, Lenore made friends with women who understood and valued her work. Two of these women, Judy Roitman, a logician and Bonnie Miller, an astrophysicist, were particularly important for Lenore.

"Without their friendship, I could not have accomplished what I have," she says. "When I felt down and out, they boosted my spirits. And when things went well, they cheered me on. Even today, we keep in close touch, though we now live in different parts of the country."

The situation began to change. By the middle of the 1970's, women mathematicians were becoming more visible. They were invited to present their research results at important professional meetings. They were elected to high positions in the professional associations. This kind of activity is very important for the career growth of mathematicians.

By the end of the 1970's, women mathematicians were getting better jobs, some in top departments. Indeed, by its tenth birthday, the AWM had brought about many important changes for women in mathematics.

A New Direction

In the fall of 1973, Lenore was hired to teach a class in college algebra at Mills College, a women's college in Oakland, California. She thought the course was dull. It repeated high school work and didn't seem to lead anywhere. In the middle of it she said, "I am going to teach you something much more useful--calculus!" Then and there, she realized that a carefully designed "pre-calculus" course could open doors for many women.

Some girls drop mathematics in high school because they think it's hard and boring. They think it's not important for their future. Then, when they get to college, they want to enter fields like medicine, business, engineering and computer science, which require a knowledge of higher mathematics. A good pre-calculus course can introduce them to calculus and higher mathematics. It helps bridge a gap for women students.

Lenore helped her students feel the excitement of mathematics and helped them gain confidence so they could really do it. She taught them to look for pictures in equations. Is it a straight line? Is it a rising curve? She showed them that people solve problems in different ways. Sometimes, guessing is a good way.

She said, "You can learn these things; you don't have to be born a math whiz."

Lenore always knew that what she was saying was much bigger than this one class. This one class grew into a program. Lenore became Head of the new Department of Mathematics and Computer Science at Mills College.

Students at Mills started to study calculus, computer science, statistics--courses that would help women enter fields that they did not even think of in the past. Some new fields for women to consider were science, engineering, medicine and economics. By 1980, more students at Mills were taking classes in mathematics and computer science than in any other subject. They were also getting summer jobs in these technical fields. What a change!

The Math/Science Network

Meanwhile, progress was being made on other fronts. At the Lawrence Hall of Science in Berkeley, after-school classes in mathematics and science were being offered for grade school students. Nancy Kreinberg, a director of the program, noticed that very few girls were taking these classes. She decided to do something about this. She started "Math for Girls."

"Math for Girls" is a special class for six- to twelve-year-olds. Here, young girls get together to solve puzzles and play challenging games--activities which help develop important problem-solving skills. Their teachers are college women who enjoy mathematics, science and engineering.

Nancy worked with young girls and Lenore worked with college women, but soon they found out they had a lot in common. One summer afternoon in 1975, they met with like-minded scientists and educators to share ideas. Quickly, this group realized they were onto something big. They could combine many resources and talents in the community and create a powerful force for change. The Math/Science Network was on its way!

Lenore and Nancy took their message across the country.

"Encourage young women to take as much mathematics as they can," they said. "It's important for their future." Thousands and thousands of young women heard this message as they attended Network events.

It was thrilling to make important things happen. But where was the little girl who liked to go off, do mathematics, make drawings, and dream?

Pulling in the Reins

With the coming of the 1980's, Lenore pulled in the reins. She decided to return to her work as a research mathematician.

Taking a leave of absence for a year from Mills College, Lenore returned to MIT. Manuel and Avrim, her family, stayed on the West Coast, where Lenore visited them frequently. She continued to lecture at universities around the country on women and mathematics.

Back to Research: Mathematics and Computer Science

In her research, Lenore uses mathematics to study why some problems are hard for computers and why some are easy--and why some problems can't even be solved at all!

Several years earlier, she and Manuel had written a paper together. They were interested in designing computers that could learn from examples in much the same way young children do. Lenore's new work explores these ideas further.

Research goes very slowly. "Some days," Lenore says, "I may sit at my desk for hours and scribble only a few lines. But each day, my understanding increases, and I begin to see things fall into place. I view my work as the beginning of a ten-year program."

Finding interconnections between her work and other projects, working among creative people who value her work--these are Lenore's rewards.

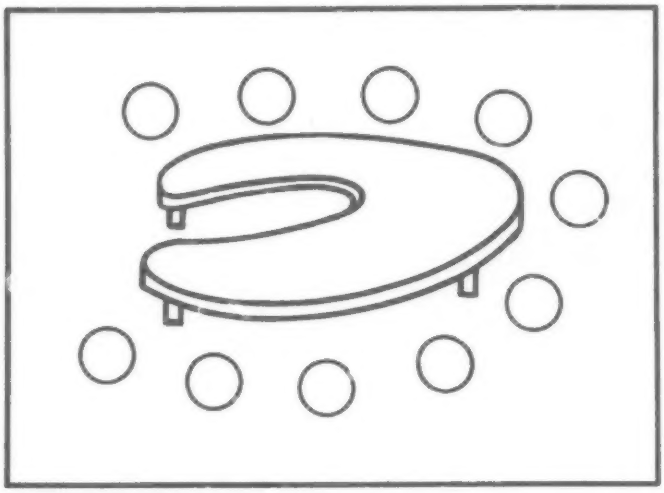
"It's exciting," she says, "to talk with other people and see how what we do fits together."

The Math-Science Network Today

Lenore helped start the Math/Science Network, a San Francisco-based group. The Network encourges young women to study mathematics in order to qualify for many careers, such as engineering, medicine, and computer science.

The Math/Science Network meets once a month. At the meetings people talk while seated around a horseshoe-shaped table. Let's pretend that there are ten people at this meeting. Who is sitting where? Can you figure it out?

Lenore is seated to the left of Len (not necessarily next to). Elizabeth is to the left of Lenore. Nancy is between Rita and Len, with Rita on her right. Elizabeth is to the right of Diane and Carol is left of Len. Carol is between Jan and Elizabeth. Flora is between Lenore and Elizabeth. Oh yes! And Lucy comes in late, walks to the end of the table, and sits down next to Rita.



(Move names on slips of paper. Much easier that way!)

MULTIPLES OF 3

There is an easy way to find out whether a number is a multiple of 3, since all multiples of 3 have a **digital sum** that is 3, or 6, or 9.

What is a **digital sum**?

You know what an ordinary sum is. A digital sum is the result of adding **digits**. Every number has a digital sum which is found by adding its digits. Here are some examples of how to find the digital sum of a number.

- 26 is a two digit number. Its digits are 2 and 6. Its digital sum is 8 since 2 + 6 = 8.

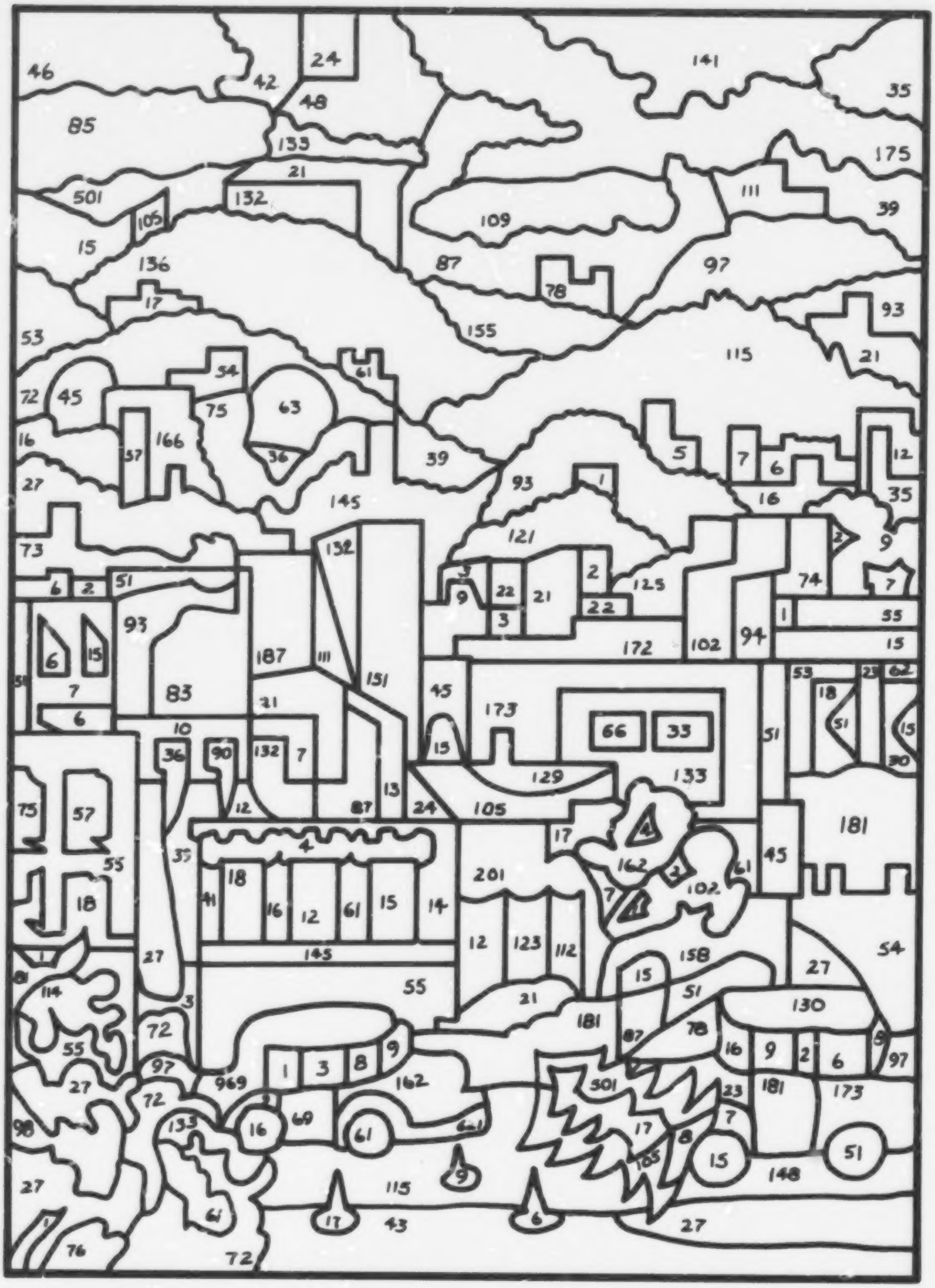
- 45 is another two digit number. Its digits are 4 and 5. Its digital sum is 9 since 4 + 5 = 9. (45 is also a multiple of 3 since its digital sum is 9.)

- To find the digital sum of 458, add 4 + 5 + 8 to get 17. Since 17 is not a one digit number it is not the digital sum we need. Continue to add 1 + 7 to get 8 which is the digital sum of 458. (Remember, the digital sum we want to look at is a one digit number from 1 through 9.)

- To find the digital sum of 525 add 5 + 2 + 5 to get 12. Then add 1 + 2 to get 3 which is the digital sum of 525. Since 3 is a multiple of 3, 525 is also a multiple of 3. (If you don't believe this, divide 525 by 3 to convince yourself.)

Practice your new, fast, test for multiples of 3. Shade all multiples of 3 to complete the picture of Caracas on p. 96.

CARACAS **SHADE ALL MULTIPLES OF 3**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EVELYN BOYD GRANVILLE

1924-

An Unusual Journey

When Evelyn Boyd was eighteen years old, she found herself on an unusual journey. She was heading north to Smith College in Northampton, Massachusetts. This was an exciting trip for the young woman, for she had rarely traveled any distance from home before. She was not worried though. After all, she was traveling with her mother, Julia, to whom she was very close, and her Aunt Louise.

Louise was her mother's twin sister. Louise had never married and was almost a second mother to Evelyn. It was Aunt Louise's car that the women were traveling in. The car was a brand new 1941 Dodge, so new, in fact, that Aunt Louise was not yet comfortable driving long distances. The women were being chauffered by a cousin who had come all the way from Detroit to Washington, D.C., to drive them to Massachusetts. Evelyn grew up in this kind of family--where people helped each other; in fact, they went out of their way to help each other.

What was Evelyn thinking about as she was driving to college? Perhaps she was thinking about the comfortable world she was leaving behind--her home, her friends, school and teachers who had been so supportive and inspiring.

Evelyn and her family were of very modest means and Black. She grew up in an all-Black neighborhood. And although this neighborhood was just a few blocks from some of the most elegant parts of Washington, D.C., Evelyn felt neither envy nor that she was different. There was a lot of caring in her family and the world seemed like a rich place.

When she was very little, she lived in a tiny apartment in a building where her father was a caretaker. Later, when he separated from her mother, her mother supported the family on a modest, though secure, salary. Julia was a civil service worker in the U.S. Government Bureau of Engraving and Printing. Although her father continued to visit the family from time to time, it was her mother who supported them.

As a child, Evelyn was shy. She looked up to Doris, her sister. Doris was less than two years older than Evelyn, but to the little girl with the big brown eyes and black braids, Doris was big and important.

Summer Fun

Summers were an especially happy time. The family couldn't afford a fancy summer camp for the girls, but there were many things to do at the neighborhood playground. Evelyn joined the arts and crafts program and played games like potato races. What she liked most of all was the library.

"The library was such a pleasant place . . . so quiet and serene. I was fascinated by China, and the Chinese people, and my favorite book was *Yung Fu of the Upper Yangtse*. I read it over and over."

Evelyn and Doris often spent a month in the country with Miss Lucy Booker, an old family friend. Miss Lucy Booker cleaned Washington houses in the winter and spent the summers at a farm she and her husband owned in linden, Virginia, in the country. Sometimes she boarded children from the city and that was how Evelyn and Doris came to go there. Life on the farm was a pleasant change. Evelyn and Doris played with the animals (dogs and pigs) and helped to care for them. Since there was no electricity on the farm, Miss Lucy put the milk and butter in the creek where it kept nice and cold.

First in the Class at Dunbar High

Back in Washington, Evelyn attended neighborhood schools. The time was the 1930's and schools were segregated. All the teachers and students in Evelyn's school were Black. School was a happy place for Evelyn. She was bright and she didn't mind working hard. In mathematics, she was at the top of her class and she did well in the other subjects too. When she graduated from junior high school, she was salutatorian of her class, which means second in class standing. At the end of senior high, she was valedictorian--first in her class!

Her high school, Dunbar, was an unusual school. The students were hard-working. Success meant a lot to them. Most all of them went on after high school to college, and many of these colleges were the upper-class, Ivy League colleges like Smith, Vassar, Mt. Holyoke, Amherst, and Wellesley. The teachers at Dunbar were strict and had high goals for their students. They inspired the students to achieve at the highest levels. Evelyn's math teacher, Miss Mary Cromwell, suggested that Evelyn apply to Smith College. Two relatives of Miss Cromwell had graduated from Smith, so it was a place not unknown to Blacks.

Evelyn applied and was admitted, but she was given no financial aid the first year. Because the family had so little money, the admissions officers at Smith may not have believed she would really go there.

Yes, her family had little money, but they had faith in themselves. Her mother had always saved as much as she could for her girls' education. She contributed $500 toward Evelyn's freshman year expenses. Aunt Louise contributed another $500 to help her favorite niece. There was another $100, which was one-fourth of a scholarship from Phi Delta Kappa, a national sorority for Black women. Altogether, Evelyn went off to Smith with $1100 for that year's tuition and living expenses.

Life at Smith College

Classes were no problem for her. She wanted to major in mathematics and physics, and so she did. Her first encounter with astronomy gave her a passion for the subject. In fact, it was her astronomy professor, Miss Williams, who helped Evelyn get her first summer job in industry, after her freshman year.

Socially, Evelyn felt she was accepted there. Smith was a college for women so Evelyn, who had never dated boys during high school, did not feel left out of a social whirl. It was World War II, many boys were gone to war, and there was very little weekend partying at close-by men's colleges.

As far as expensive clothes were concerned, the young women at Smith wore jeans to class, and mostly on weekends too, and Evelyn did too. After her first year, Evelyn lived at a co-op house, where students took turns sharing the chores, like serving at table, and living there was less expensive than at the regular dormitories.

When Evelyn was still in high school, she planned to become a teacher. This profession was well paid and highly respected within the Black community. Now that she was at college, though, Evelyn thought of other possibilities--perhaps becoming a physicist or mathematician in industry.

In 1945, Evelyn graduated from Smith and the world seemed to welcome her. It felt quite natural to go on to earn an advanced degree in mathematics. She received a fellowship from Smith College, and financial aid from Yale, and with these she was admitted to Yale University to study for the doctoral degree. She received Yale fellow'ships for the next two years and during the last year was an Atomic Energy Commission Postdoctoral Fellow.

Setting a New Record

It is difficult to imagine what a triumph this was for the young woman. She herself does not seem to appreciate how outstanding an accomplishment. It was astounding that a woman, a Black woman, be admitted to such a program at that time in the history of our country. Although she was not aware of it at the time, Evelyn, together with Marjorie Brown at the University of Michigan, were the first Black women to receive doctoral degrees in mathematics--ever! The year was 1949. Evelyn set a record and she was not aware of it until much later in her life.

Yale was lots of fun. Evelyn had a circle of friends, young men and women, and enough money for occasional train trips to New York for a day of shopping and theater. She studied hard but also had time to enjoy campus life.

Evelyn graduated from Yale with her Ph.D. in mathematics and a college physics major behind her. She was not personally aware of discrimination against Blacks and women as she looked for her first job. The United States was just launching its space program and Evelyn's background was tailor-made for jobs in this program. Still keeping her mind open to possibilities in college teaching, Evelyn had an interview at a New York city college. Years later, she was told by a colleague the "behind the scenes" truth about that interview: because she was a Black woman, the interviewers had never seriously considered her for the job--Yale doctoral degree or no!

New York--Not Like Home

Her first job was at New York University's Institute of Mathematics and Science and of course Evelyn had to move to New York. To her, the city was all noise, dirt and concrete. Apartment hunting brought her face to face with "de facto" housing discrimination. This means that, although housing and apartments were not segregated by law, old attitudes on the part of landlords caused Evelyn to have a very hard time finding an apartment to rent. After looking and looking, she moved in with another Black woman who was a friend of her mother's.

Settling Down at Fisk

After a year, she decided to leave New York City for a job she really wanted, teaching at Fisk University, a well-known college for Black women and men in Nashville, Tennessee. Evelyn went to work at Fisk as a mathematics instructor.

At the opening of the school year, the President of Fisk introduced the new faculty. When he came to Evelyn and described her education and achievements, there was a gasp from the audience.

Speaking of herself, Evelyn says, "It was *wonderful* for a woman to have that background. That in itself was an inspiration to the students."

Evelyn taught undergraduate mathematics courses for the next two years. Several women students later mentioned Evelyn in their doctoral dissertations, giving her credit for inspiring them.

By this time, Evelyn had abandoned her first love--astronomy. Life among the stars, millions of miles away, was fascinating. Yet jobs in astronomy, here on earth, were lonely. Astronomers worked at observatories located far from cities, from people and from social life. Evelyn enjoyed being with people. She was discovering this over and over. At Fisk, she lived in a large house with other members of the faculty. She liked the close interaction with her co-workers.

The Space Program--Fascinating Work

In the 1950's Evelyn worked at IBM and was closely involved with the first missile program in the United States--called Vanguard. She worked at the Vanguard Computer Center, sometimes in New York and sometimes back home in Washington. The work was fascinating and made good use of her training in functional analysis. Answers describing the inside workings of the rockets were fed into computers to guide the Vanguard satellite, and evelyn made "on-site" calculations at the main viewing area when the satellite was first launched. This was the most interesting job she had in industry.

One year, on a summer vacation, Evelyn's life took a sudden turn. She had gone to southern California to visit a friend and there she met and later married her first husband. He was a minister in the Community Church. In 1960, Evelyn, now married, moved from the East Coast to Los Angeles. She was 36 years old.

Using her long experience in the space program, she applied and got a job at Space Technology Labs (STL) as a mathematical analyst, one who studies rocket trajectories. She was one of few women and the only Black at this job. As before, she was well treated by her male co-workers. Still, they had their own social group and she had none.

Making Friends and Influencing People

How was she to make friends in the brand new city? One way was through the church. As a young girl and a teenager, she was very active in her church. Now she joined her husband's church. He had a special job. He was part of a group of ministers who raised funds for Martin Luther King, the celebrated Black leader of the Civil Rights Movement. Evelyn's husband helped to organize large rallies when Dr. King came to town. Evelyn met Dr. King several times and thought he was a fascinating person.

During this period, Evelyn was asked to speak three or four times a year at Women's Day Programs at churches. These programs were held in connection with civil rights events. Though she was a little nervous as a public speaker--she hadn't really done it before--she learned to carry off her speeches gracefully.

By the end of the 60's, Evelyn was working again at IBM and people all around her were being transferred, because IBM did not win a large contract from the government for work in the Los Angeles area. Evelyn's supervisor, who did not want to lose her to the company, urged her to transfer to IBM in northern California or back to Washington. But Evelyn didn't want to go.

The Right Time and the Right Place

By this time, she was divorced. She lived in the View Park area of Los Angeles and owned her own home. Perhaps, she thought, this was the time to think about changing careers. She would leave industry and re-enter the world of college teaching. She had always loved teaching.

Evelyn applied to California State University at Los Angeles--close to home. Just like clockwork, as had always happened in her life, her job at IBM drew to a close and she heard she had got the job at Cal State-L.A.

"I have always been in the right place at the right time," she says.

At Cal State, Evelyn taught mathematics for teaches and courses in compute science. Teaching had its good points and its bad ones. Students at Cal State-L.A. seemed less eager to learn, *far* less than she remembered from Dunbar High School and Fisk University. These students were weak in math and teaching them was difficult.

On the bright side, she was practicing the profession she loved.

"I have always loved to explain things, and see someone learn from that," she says.

Although she earned exactly half her old salary in industry, she joked that the only day she missed her old job was the first of the month--payday.

About this time, she began a very rewarding project. She and a co-worker at Cal State-L.A., Jason Frand, decided to write a book. The two took five years to complete it, testing it on their own classes, revising it as they went along. She remembers many grueling evenings and weekends writing and rewriting and rewriting again. The title of their book is *Theory and Applications of Mathematics for Teachers*. It has been well received and is now in its second edition.

Evelyn is a full Professor at her university. She has published a successful book in her field, and has taught for many years. She would have liked, in addition, to take the next step, and enter college administration. During the 1970's, under pressure from affirmative action laws, the status of women, especially minority women, rose in both industry and higher education. At Cal State-L.A., minority women were offered a one-year training program to allow them to become deans, department heads and administrators; in other words, to be in positions where they could influence policy.

"If I were younger," Evelyn says, "I would enter this program."

Government Pressure a Must

She hopes that the government will continue to pressure industry to hire Blacks and other minorities. She is concerned that present government policy will weaken the gains that were made in the 1970's, and that Blacks and other minorities will again be rejected when they apply for good jobs.

Evelyn advises young people to "stay on your toes. Learn more than one thing, so if one career doesn't pan out, you can switch to another."

In 1970, Evelyn married her present husband, Ed Granville. Ed works in real estate and banking. They are very active in their church. Evelyn keeps the church financial records. She loves to sing and is a member of the choir. The Granvilles attend Bible Study every week and have many friends among church members.

Moving to the Country

In a few years, when Evelyn is 60 years old, they will retire and move to the country. Together with Ed's relatives the Granvilles are buying a farm in Tyler, Texas. There they will build a house, raise cattle and other animals, and grow flowers and vegetables. After life in Los Angeles, with its crowds and fast pace, Evelyn looks forward to a peaceful, pleasant life. She plans to teach part-time in nearby Tyler, and become active in the community.

Evelyn has always had a spirit of adventure and a strong curiosity. And she herself has surely learned how to "stay on her toes." It is these qualities that brought to life for her the story of Yung Fu, the Chinese boy. It is this that marked her attraction to astronomy with its study of outer reaches of the universe, that prompted her job changes, her moves and her change of careers.

Soon, another adventure beckons. Evelyn will move to Texas, close to nature and family, and close to teaching and the community.

HOW MANY SEATS?

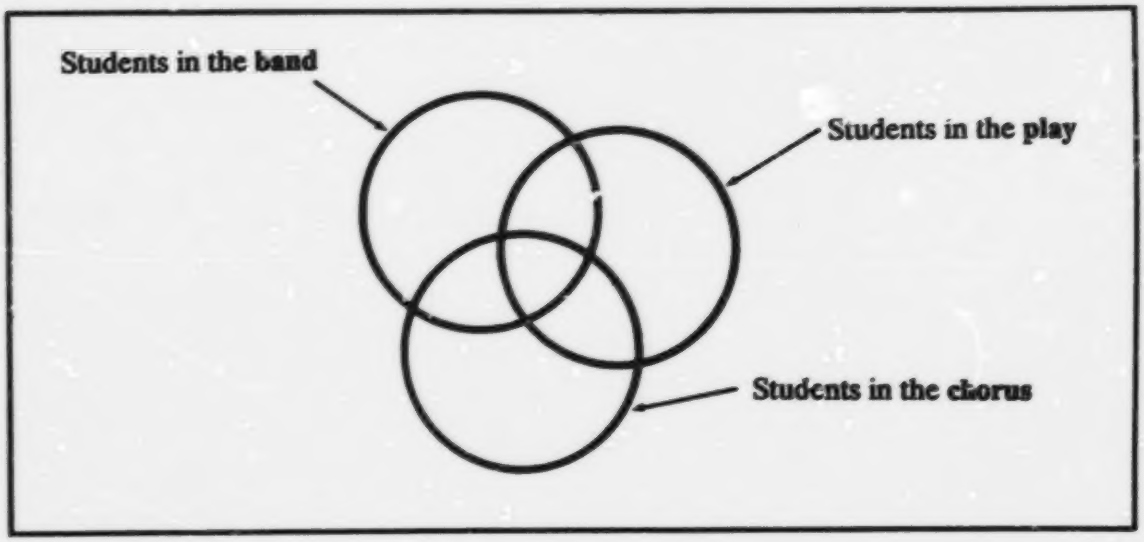
Evelyn Granville enjoys story puzzles like this one:

A bus load of students are on a trip to a school at the other end of town where they are presenting an evening of entertainment.

- Fifteen students in the band are going to perform.
- Eight students are in a play.
- Three students who play in the band are in the play as well.
- Ten students are in the chorus.
- Of these, two are also in the play.
- No students are in both the band and the chorus.
- Six students are just going along for the ride.
- Two teachers are going along to maintain law and order.

How many seats are needed on the bus, not counting the driver?

One way to solve this problem is to fill in the diagram below. Show the number of students in each activity--band, play, chorus. Show the number of students in more than one activity where the circles overlap. Then continue with the diagram and labels as you have them.



THE PASCAL TRIANGLE

One of Evelyn Granville's favorite mathematical patterns is the Pascal triangle.

Figure 01 shows a partly completed Pascal triangle. Notice each number is the sum of its two closest neighbors in the row above.

Look at the triangle and see if you can continue the pattern for at least two more rows. (Actually the Pascal triangle can be made as large as you like.) It may help to notice that the Pascal triangle is symmetric around line AB. That means if the Pascal triangle is folded along a vertical line down its middle (line AB), the numbers on both sides will be the same.

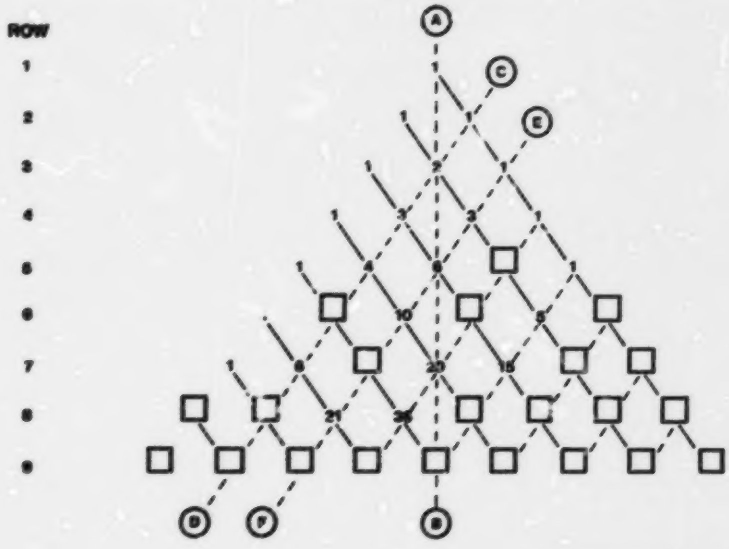


Fig. 01

The numbers that make up the Pascal triangle turn out to be a good description of activities like coin tossing. For example: If you toss one coin, only two things can happen; you can turn up one head or one tail. These are the ones in Row 2 of the Pascal triangle (see figure 01).

Toss two coins and four things can happen.

HEAD HEAD	1	[2 HEADS]
HEAD TAIL	2	[HEAD-TAIL] combinations
TAIL HEAD		
TAIL TAIL	1	[2 TAILS]

This can be summarized as
1 [Both HEAD] 2 [HEAD,TAIL] combination 1 [Both TAIL]

Notice these totals (1,2,1) in Row 3 of the Pascal triangle (Fig. 01).

If you toss 3 coins, 8 different things can happen; you can get

HEAD HEAD HEAD	1	[3 HEADS]
HEAD HEAD TAIL		
HEAD TAIL HEAD	3	[2 HEAD, 1 TAIL] combinations
HEAD TAIL TAIL		
TAIL HEAD HEAD		
TAIL HEAD TAIL	3	[1 HEAD, 2 TAIL] combinations
TAIL TAIL HEAD		
TAIL TAIL TAIL	1	[3 TAILS]

When this is summarized, you get the totals in Row 4 of the Pascal triangle. That is:

1[ALL HEAD] 3[2 HEAD, 1 TAIL] 3[1 HEAD, 2 TAIL] 1[ALL TAIL]

For 4 coins, 16 different things or events can happen. They would look like this:

HEAD HEAD HEAD HEAD	1 [4 HEADS]
HEAD HEAD HEAD TAIL	
HEAD HEAD TAIL HEAD	

HEAD HEAD TAIL TAIL

HEAD TAIL HEAD HEAD 4 [3 HEAD, 1 TAIL] combinations
HEAD TAIL HEAD TAIL
HEAD TAIL TAIL HEAD 6 [2 HEAD, 2 TAIL] combinations
HEAD TAIL TAIL TAIL

TAIL HEAD HEAD HEAD
TAIL HEAD HEAD TAIL
TAIL HEAD TAIL HEAD
TAIL HEAD TAIL TAIL 4 [1 HEAD, 3 TAIL] combinations

TAIL TAIL HEAD HEAD
TAIL TAIL HEAD TAIL
TAIL TAIL TAIL HEAD
TAIL TAIL TAIL TAIL 1 [4 TAILS]

Complete the number for each situation described below.

— 4 HEADS
— 3 HEADS, 1 TAIL
— 2 HEADS, 2 TAILS
— 1 HEAD, 3 TAILS
— 4 TAILS

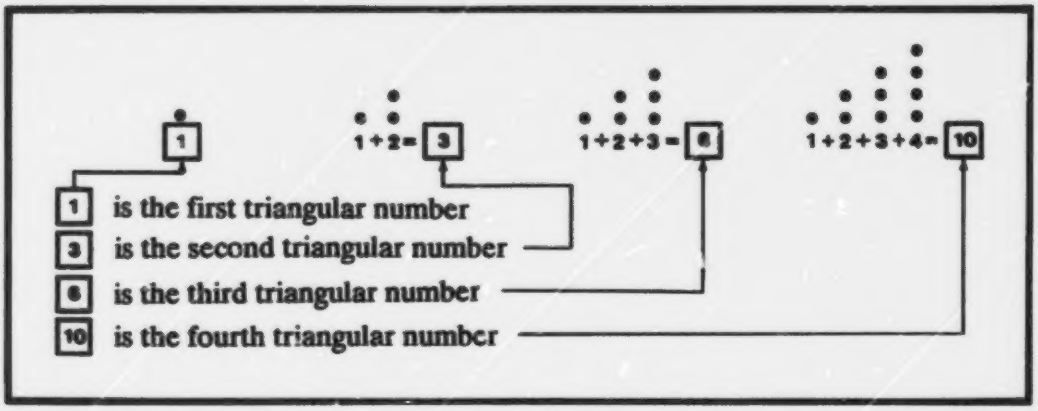
How many different events happen here? What row of the Pascal triangle shows this? (See figure 01.)

How about 5 coins? How many different events can happen? Can you enumerate all the events when 5 coins are tossed? What row of the Pascal triangle describes this?

If you think about it you will notice many other interesting patterns in the Pascal triangle. For example: Notice the 1's along the outside edge on either side of the triangle.

Now look at the numbers in line CD. Notice these numbers are the sequence of counting numbers (1, 2, 3, . . .).

Look at the numbers in EF. These are called the **triangular numbers.** Look at the diagram below and you will see why.


1
1 + 2 = 3
1 + 2 + 3 = 6
1 + 2 + 3 + 4 = 10
1 is the first triangular number
3 is the second triangular number
6 is the third triangular number
10 is the fourth triangular number

Draw the next triangular number.

Can you locate it if you continue along line EF in the Pascal triangle?

Draw the next triangular number.

Can you find it on line EF as well?

Here is another pattern in the Pascal triangle. Add the numbers across each row in the triangle and fill in column B. Then complete column C.

Notice the pattern of numbers in column B.

A	B	C	D
ROW	SUM ACROSS ROWS	MULTIPLES OF 2	POWERS OF 2
1	1	1	2^0
2	2	2=2	2^1
3	4	2X2=2	2^2
4	8	2X2X2=8	2^3
5	___	___________	___
6	___	___________	___
7	___	___________	___
8	___	___________	___
9	___	___________	___
10	___	___________	___

Each number is a power of 2. Complete column D.

This is just a sampling of the kinds of patterns that have made the Pascal triangle such an ongoing source of interest to people who enjoy mathematics.

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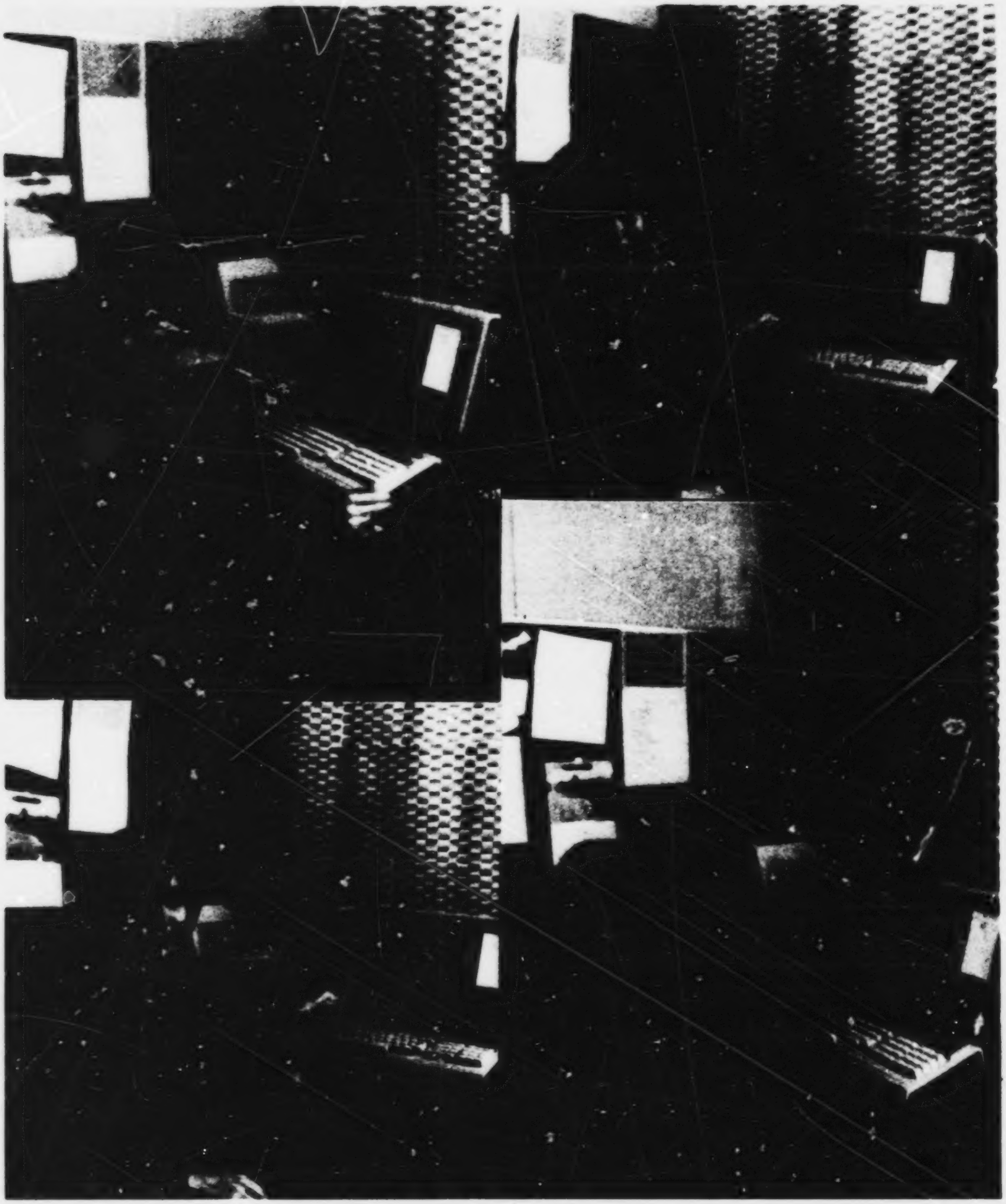

FANYA MONTALVO

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FANYA S. MONTALVO

1947-

Fanya watched her pet duck, Oscar, waddle across the narrow concrete yard on webbed feet. She had just returned from walking Oscar around the neighborhood where kids stared at the big white duck. Fanya loved the sensation she and Oscar created. She was building a corral for the duck, and she picked up her hammer and nailed a strip of wood on the corral.

Fanya was eleven years old. She liked to build things. If her family couldn't afford to buy something, she built it out of whatever materials were around. With cardboard boxes, pegboard, and paint she made herself a desk. For her friend and herself she made a dollhouse out of cardboard.

Dolls, Ducks, and a Difference

Dolls didn't really interest Fanya. She was different from some girls that way. Different in other ways too. Oh yes, her apartment house looked like all the others on the street, and that street looked like all the others in Logan Square, her section of Chicago. Her duck, she supposed, looked like any other white duck pretty much. It wasn't any of those things. It was she herself. Her skin was more olive than most, and her language was not quite like the others in her class. Fanya understood textbook English just fine. But it was hard to understand expressions, slang, and jokes, and often she felt left out if she didn't understand what was being said. Dollhouses and corrals were easy, but the English language--ooy!

Five years before, when Fanya was six years old, she had moved with her family from her birthplace in Monterrey, Mexico. Fanya's father was a radio and tv repairman.

When Fanya was only one, he had come to the United States to find work. Staying here, he worked hard and saved his money. With a friend as his partner, he bought an apartment house in Logan Square. This section of Chicago had no Mexicans. Here he moved his wife, three sons and his daughter, Fanya.

The family returned to Monterrey for vacations. The trip in the family Dodge took about three days. Monterrey was due south of Chicago about 1300 miles. If the distance had been 13,000 miles, the two places couldn't have been more different.

In the United States, the Montalvos spoke Spanish at home. On this their father insisted. He wanted his children to be proud of their heritage. When they went to Monterrey, they renewed contact with that heritage. They had fun with their relatives and celebrated.

In the United States, the family kept to themselves. Fanya didn't want to move back though. Her life was in the United States now. She and her brothers would learn how to succeed in this new culture.

In school she had to learn English on her own. When she went to first grade, the teacher just talked louder when Fanya didn't understand her. Reading was very hard, and it took Fanya a long time to finish a book. Like many other children, she really had to struggle with this new language.

Numbers, though, were the same in Spanish and English, and mathematics was much easier for her. Problem-solving was fun. The best fun, though, didn't happen in school at all. The best fun was when her father made up puzzles for the four children to solve at the dinner table. Fanya was six years younger than her next older brother, yet sometimes she got the answer first. When that happened, they would look at her and say, "That little one; she is clever!" Her mother was proud of her daughter who was so good at reasoning.

The Physics of Things

Fun was also jokes with her brothers--teasing and playing with them. Her brother Ramiro began to study physics in college. He asked her questions about the physics of things. He told her about the theory of relativity.

"Suppose you had a spaceship going at three-quarters the speed of light and another ship goes by it at a passing speed of three-quarters of the speed of light," he would say. "How fast is the second ship going?"

"One and a half times the speed of light," Fanya would answer.

"No!" Ramiro would say, "Nothing can go faster than the speed of light."

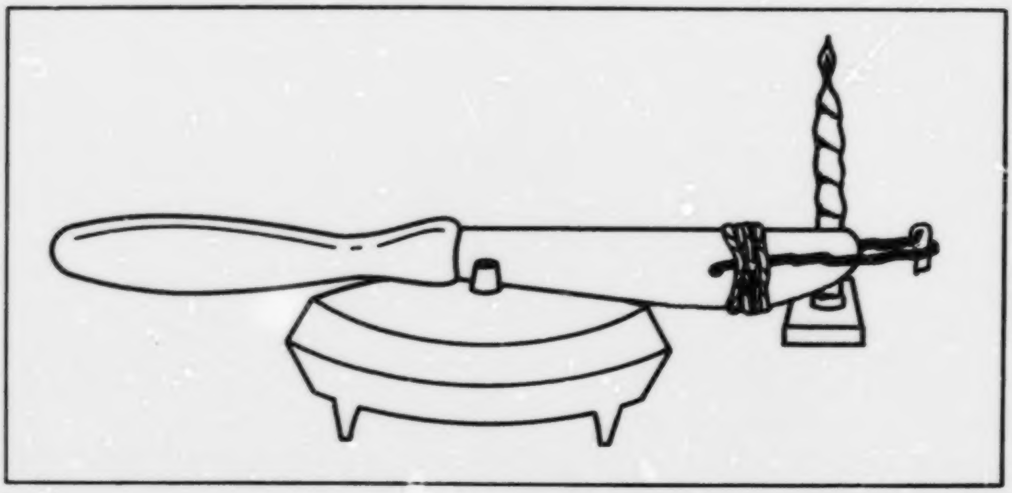
Then he would try to explain to Fanya why that was so. She was terrifically excited by it. About this time she read a book called *One, Two, Three, Infinity,* by George Gamow. It was a book about physics for teenagers that had "wonderful puzzles and paradoxes in it."

Mathematics was fun too. Without trying very hard, Fanya got 100's on quizzes. She liked to work things out for herself with no help from others.

A Kitchen Experiment

One year, when she was in seventh grade, Fanya showed the class at school an experiment she worked out at home. She made a rocket from tinfoil and a wooden matchhead.

This was the way she made it. She took the head off a flat kitchen timer and inserted a butter knife in the slot of a shaft so that when she set the timer, the knife rotated slowly.She placed a lighted candle so that at zero, the knife would move over the candle and become heated. At the end of the knife handle she constructed a small platform with a bobby pin, and set on the platform a tiny "rocket." The rocket was a wooden matchhead with the stick broken off, and an exhaust channel made with a pin in its base. The matchhead with a pin stuck in it was wrapped tightly in foil. The exhaust channel was formed by the foil surrounding the pin. Then the pin was removed. The knife moved over the candle, heated up, heated the space inside the "rocket" and–blast off! It flew up and halfway across the classroom.



"It was great," Fanya recalls. It wouldn’t flame very much. Just go with a soft ‘whoo-sh’.

"Some of the kids in the class were surprised that I could do experiments with fire. When I became interested in candles and matches at a younger age, my mother let me play with them in front of her until she knew I could handle them safely. I was proud of my parents for this." (IMPORTANT! Parents or responsible adults must look over all experiments with fire and explosives **first**, before they are set off.)

Fanya attended a Catholic girls’ high school. She made friends with a classmate named Sue. Sue and Fanya are friends to this day. "She is my oldest, dearest friend," says Fanya. Sue was fun. She liked boys and they liked her. Fanya and Sue hung around together. They went to each other’s house after school. They went to the beach out on Lake Michigan in the summer. They listened to records and went to dances. Sometimes they double-dated.

Sue taught Fanya how to use make-up. "I felt my looks were totally non-standard," Fanya recalls. "The standard look was Anglo--blond and beautiful. I was dark and swarthy and flat-chested and skinny. I was everything you weren’t supposed to be in the late 1950’s and early 60’s. I didn’t feel very attractive at all in those years."

Moving Up in Math and Science

Because of her slow reading, Fanya tested poorly in high school entrance tests. She was placed in the lowest academic track. But she immediately began to move up in mathematics and science. It took awhile longer in English. Fanya remained fluent in Spanish, her native language. In English she worked hard, and by senior year moved to the middle track. In science and mathematics she was in the top group, taking honors math.

In geometry class, Sue asked Fanya for help and Fanya tutored her. Sue got an "A" on the next test. The teacher called Sue in and accused her of cheating. "No," Sue explained, "Fanya has been working with me." Oh, that was all right then.

Fanya felt very proud but she didn’t really work hard herself. She got by with B+’s. It took her some years before she could discipline herself to work hard for a goal she set herself. As a student, she didn’t take herself that seriously.

Fanya followed in Ramiro’s footsteps at college and majored in physics. She attended Loyola University, a Catholic university in Chicago. There were no other girls in physics but, Fanya reasoned, "I’m already different. I’ll go into this field."

Fanya loved physics. What are things made of? Why does heat rise and cold sink? What makes light travel? What rules govern the universe?

Problems of a Professional Woman

By sophomore year, the problems of being a "professional technical woman" were beginning to surface. First of all, there was a huge change at home. Ramiro, ten years older than Fanya, left home that year. Gone was her affectionate older brother. Gone was her intellectual friend. Fanya felt abandoned.

She wanted to make friends with the "smart kids" at school, but she felt awkward around them. She was from a humble background. Was that why she felt shy around them?

In Fanya's physics courses there were only boys. These boys were not helpful the way her brothers had been. They weren't available to work on homework assignments. The professors really didn't act helpful either.

"Well," she thought, "the whole physics department is too cold." She decided to choose another major, something more humane. She switched her major to psychology.

With her strong mathematics background, Fanya went into mathematical psychology. After a psychologist chooses a question about human behavior to explore, a mathematical psychologist takes that problem and finds ways to measure it. Fanya, for instance, learned to chart and graph statistics in her courses.

Fanya still did not think she was anything special as a student. In fact, when a professor counseled her in her senior year to enter graduate school, she argued with him:

"Look. I want to graduate, get a job, get an apartment and have my own money.

"I don't know what branch of science I'm really interested in. Basically, I want to find a man who is a scientist and smarter than I am, marry him, and raise a family!"

The professor laughed at her and referred her to another psychology professor named Naomi Weisstein, who was teaching a course about sensory perception the coming semester. Fanya signed up for her course and Naomi Weisstein helped her change her life.

A New Way of Life

Fanya joined Naomi and her circle of friends. This group was high-spirited and liked to have fun as well as work hard.

Naomi recognized Fanya's talent and offered her a job. After graduation, Fanya went to work. She became head of Naomi's vision lab at Loyola University. At last she had a job, her own money, and her own apartment.

During the two years she held this job, she had time to think about her goals. She needed the freedom to explore her love of science. Marriage would wait. She wanted a full chance to try out her new life before looking for a partner.

As head of the lab, Fanya helped design and set up experiments in vision. Human "subjects" would sit in darkened little rooms for hours and look through tachistoscopes. These machines flashed visual stimuli or pictures for one-fifth of a second or less. The object of the experiments was to learn how human beings see objects and translate what they see to the brain. Fanya and Naomi published a paper together about these experiments.

After two years, Fanya was getting bored. "Go to graduate school," Naomi urged.

Fanya still wasn't sure she was good enough to go on, but with support from Naomi, her new friends and co-workers, she enrolled in a masters program at the University of Illinois in Chicago.

During this year she studied all sorts of subjects that would be very useful later in her studies and work. The courses were in television, signal processing, systems theory and frequency analysis. The people in her classes were mostly electrical engineering students.

The CWLRB

About this time, Fanya, Naomi and their friends decided it would be a good idea to start a women's rock band. Rock music was performed mostly by men, but the "Chicago Women's Liberation Rock Bank" or CWLRB would change all that!

Fanya wanted to sing, but as a band soloist she wasn't too hot. "Do something else," the others said.

Someone had given the drums up and they were just sitting there. "I started to play them just to keep time for the rest of the band," she says.

"Hey, you're pretty good!" they said.

And that's how she became the drummer of CWLRB.

"Don't go too fast but I go pretty far,
For someone who don't drive I've been all around the world,
Some people say I've done all right for a girl . . ."

--Lyrics from "I've Got a Brand New Pair of Rollerskates"
by Melanie

Fanya loved performing. When she entered the University of Massachusetts (U-Mass) Computer Science Department to earn her doctorate degree, performing came in handy. Giving papers at conferences was a top requirement for the doctoral students, and Fanya could put on a good show.

U-Mass wasn't Fanya's first choice. The top places in her field--MIT (Massachusetts Institute of Technology) and Stanford University--turned her down. Her record was not quite good enough. U-Mass was a step down from these universities but still it was a very good place to study.

The head of the department was a friend of Naomi's named Michael Arbib. He accepted Fanya as his research assistant. She became one of a select group called "Arbib's Kids."

Out of eighteen doctoral students only two were women and the other woman did not arrive until Fanya was nearly finished with her graduate work. But taking courses in computer science at U-Mass was not like the physics courses back in college had been. Here, she got equal treatment with the men students. She was part of the group.

At U-Mass, Fanya had all the ingredients for success: a close group of co-workers, a leader who was inspiring and fair, and an atmosphere that was open to new ideas and new people. Fanya blossomed at U-Mass. Because of her gang back in Chicago, her performing with the band, and her talks at conferences, Fanya was learning new social skills.

She no longer felt unattractive. Her olive skin, intense brown eyes, dark hair and slim figure were no longer unusual. Blond hair and blue eyes were not the only standard of beauty. Times had changed.

Dr. Fanya S. Montalvo and AI

At the end of four years Fanya earned her doctoral degree. Now she was Dr. Fanya S. Montalvo. She was ready for new adventures and wanted to live in a new place. Perhaps California.

Back when Fanya had worked in Naomi's vision lab, Naomi introduced Fanya to a branch of Computer Science called Artificial Intelligence, or AI as it was known. Researchers in AI study how the brain works, and try to design computer programs that act like people. Fanya was fascinated. She looked for a job in this field.

To get a job in AI "you needed to come out of one of the top three universities with AI labs," she explains. Instead, she took a job in California at Lawrence Berkeley Laboratory.

Her position at the lab was a post-doctoral. She continued the work she had done on vision in her doctoral thesis by applying this work to computer graphics.

She kept her eye on developments at Stanford AI Lab, which was fairly close to Berkeley in the San Francisco Bay Area. She sat in on a course at Stanford. Her teacher had constructed a computer language called FOL, which meant first-order logic. The language did not use numbers, nor did it use words. Instead, it used symbols such as are taught in the study of logic, a branch of philosophy. Her teacher built a structure in the computer that could move these symbols around.

"A lot of what he was thinking about was what I had been thinking about," says Fanya, "so I invited him to lunch to talk about it. Secretly, I was hoping he would offer me a position at Stanford AI Lab.

"Instead he said, 'Oh, they're looking for people to do this kind of work at Hewlett-Packard Laboratory.'"

Soon after, Fanya applied for a job at Hewlett-Packard, which is near Stanford and has close ties to the AI Lab there. She was hired as a research scientist in AI at Hewlett-Packard, a job she holds today.

"I really love this job," she says. "I feel like I'm on the cutting edge of science. Building intelligent machines is the next step in computer science. Artificial Intelligence is really the study of the mind.

"Imagine a science in which we're looking only at patterns, not the materials the patterns are made of. It's like the study of flight. You can study flight in birds or in airplanes--or even in paper airplanes. It doesn't matter--the principles are still the same.

"So, too, with the study of mind. When you study mind, you study complicated patterns, and those patterns can exist in brains or in machines."

Building a Smart Machine

"I was always fascinated by Isaac Asimov's idea of a computer that could make another computer just like *itself*, but only a little smarter. Then that machine, in turn, would know how to build one a little smarter than *itself* . . . and so on and on, until one would be built to equal or surpass human intelligence. It *could* happen.

"There's no reason we have to build machines as violent or aggressive as we are. These machines may even be kinder and more peace-loving than we are. War may not make any sense at all to them.

"Doug Hofstadter, an AI person who writes for Scientific American, describes an interesting idea (May, 1981, issue). Suppose the military put enough money into AI to build smart bullets, bullets that turn around in mid-flight because they don't want to commit suicide."

When Fanya talks about these interests her face lights up and her hands move excitedly. She has interests outside of her work too. Skiing is one of her hobbies and two years ago, for the first time, she bought a skateboard. She often bicycles to work, and can be seen walking around the Stanford campus wearing a backpack.

Music is another interest. Fanya sings medieval ballads in a madrigal singing group. She plays guitar and piano, and sings folk and country songs.

Her voice is light and melodic with a bit of country twang:

"Don't go too fast but I go pretty far,
For someone who don't drive I've been all
around the world,
Some people say I've done all right for a girl . . .
. . . or a boy, man or woman!

Fanya likes to write poetry. This is a poem that Fanya wrote in October, 1979:

SYMBOLS

Rings and groups
circles and FlooPs
generate numerous levels of loops.
Strange,
to be tangled in
Gordion GlooPs.

BlooP

to a space of disorderly soup.

Fanya's poem is about thinking too hard on the same track . . . getting stuck in a loop. That is what the Gordian Gloop refers to.

To get out of the rut . . . to get a fresh new idea . . . may require a leap of imagination. That's what the Bloop is about.

FlooPs, GlooPs and BlooPs refer to specific types of computer programs . . . Floo Programs, Gloo Programs and Bloo programs. This is explained in Douglas Hofstadter's book *Godel, Escher, Bach.*

FIBONACCI NUMBERS

Complete the picture of Fanya's pet trurl on page 126 by shading in all the Fibonacci numbers.

Fibonacci is the name of a mathematician who lived in Italy in the 13th century. A number sequence which has many interesting properties is named after him.

This sequence goes on forever. It has no LAST number. Mathematicians call such a sequence an **infinite sequence.**

This is the rule for generating such a sequence:

The first number is 1, the next is also 1. From then on, each number is the sum of the two preceding numbers.

The sequence starts like this . . . 1, 1, 2, 3, 5, 8, ___, ___, ___, ___,

The easiest way to do this fill-in is to make your own list of the first 16 **Fibonacci Numbers** to have at your side. Use this space:

Fanya's pet, **Trurl**, is a small crested parrot with lovely gray and yellow plumage.

Trurl is named after the main character in one of Fanya's favorite science fiction books. *Cyberiad*, by Stanislaw Lem, is a collection of short stories about the adventures of Trurl, the Universe's greatest builder of intelligent machines. Such people are called **cyberneticians.**

Trurl can speak a few phrases.

He can say "pretty bird."

He can say "Trurl is a pretty bird."

And, according to Fanya, he whistles very nicely.

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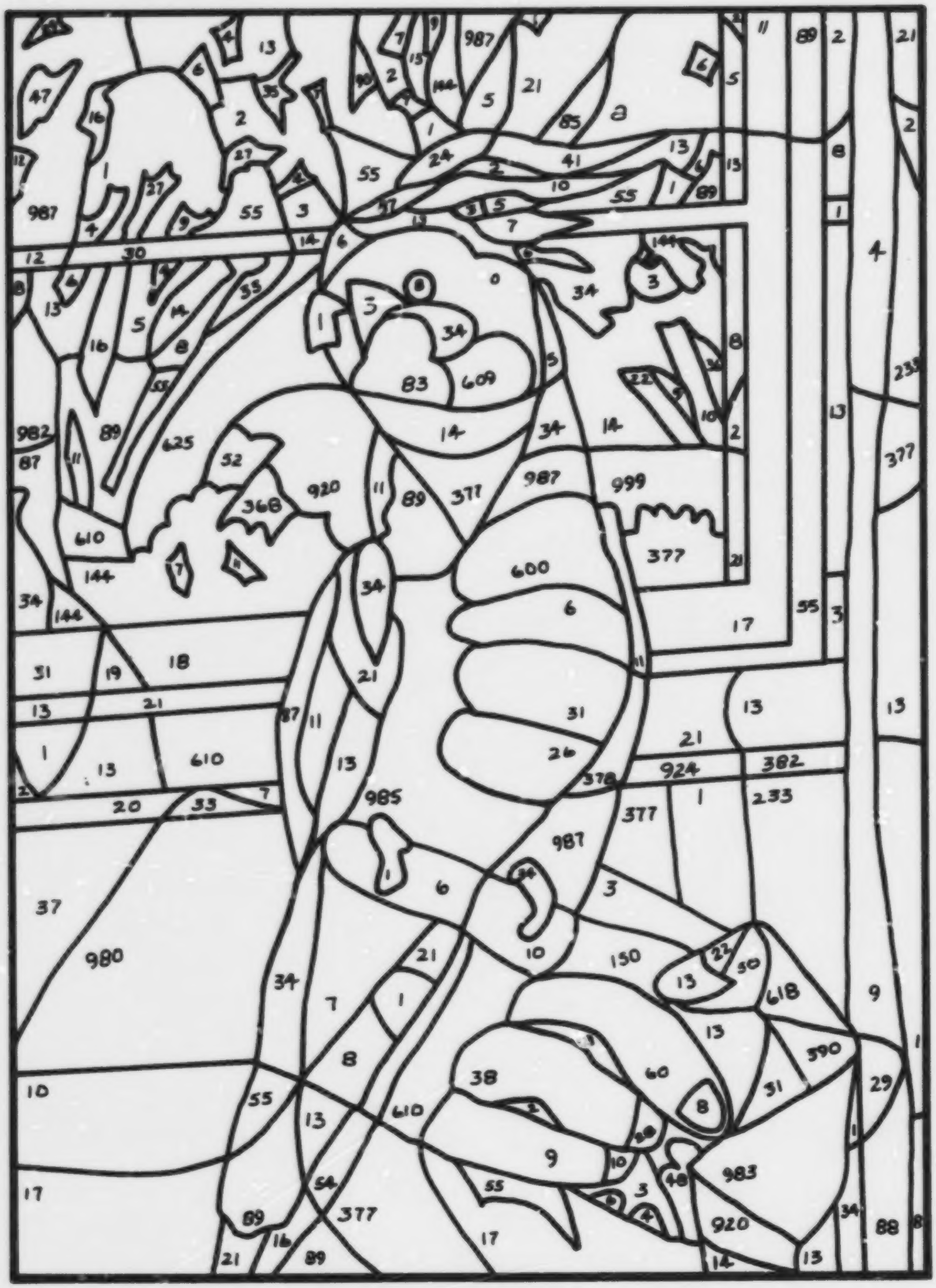
FANYA'S PET TRURL **SHADE ALL FIBONACCI NUMBERS**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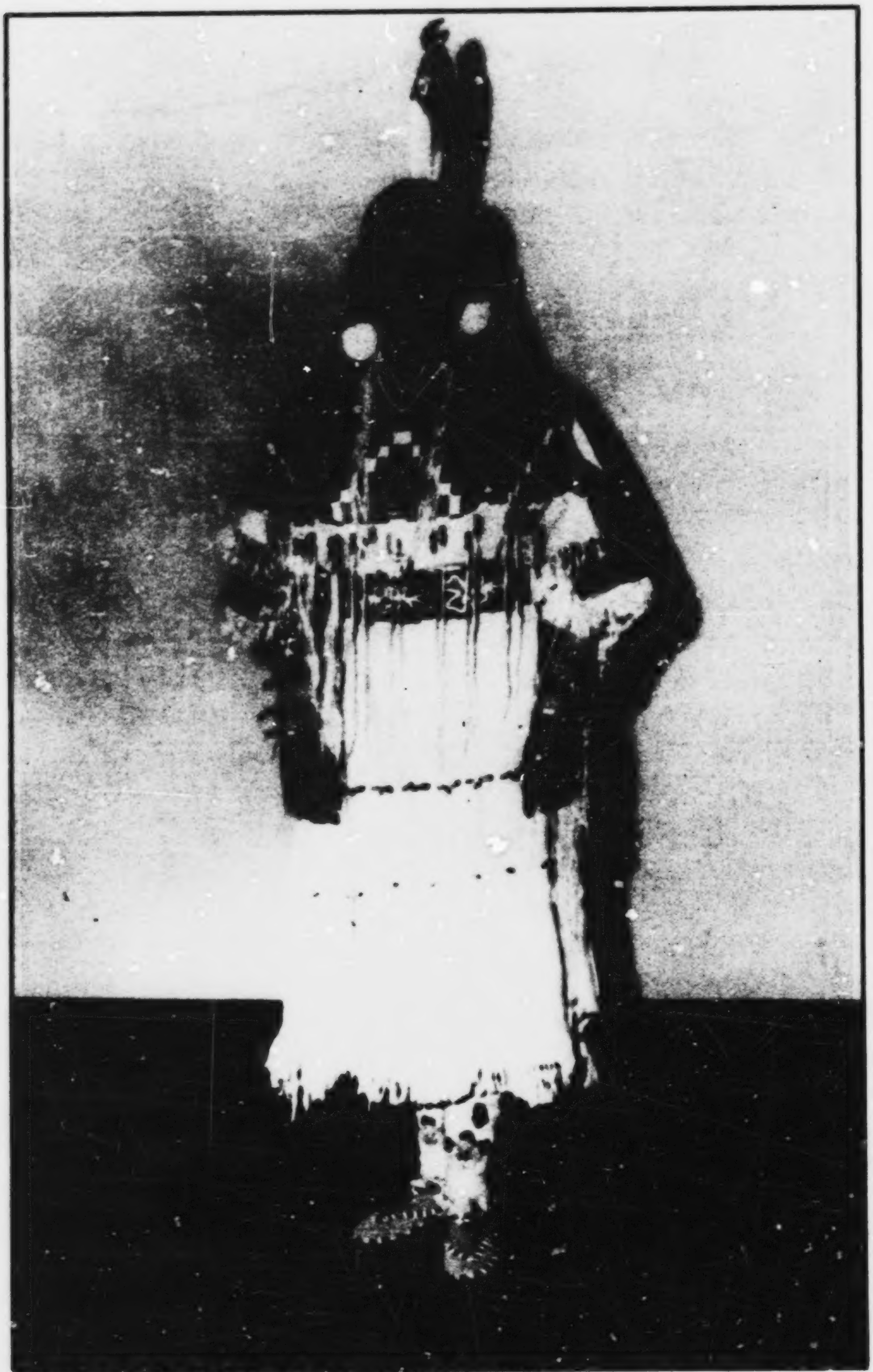

EDNA LEE PAISANO IN BUCKSKIN DRESS
ANNUAL TOURNAMENT, NEZ PERCE RESERVATION, LAPWAI, IDAHO, CIRCA 1965

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EDNA LEE PAISANO

1948-

Life on the Nez Percé Reservation

Inside the tepee, the girl watched the fire. At the same time, she kept careful watch on the cat to see it didn't get to the meat. Strips of deer, moose, and elk meat hung by the wood fire. As she watched, her mother added more wood to the banked fire and her grandmother turned the cooking meat.

It was the mid-1950's, and Edna Paisano was eight years old. The tepee was set up in the backyard of her family home, near the town of Sweetwater, Idaho. The town is Nez Percé tribal land. By treaty with the United States Government, the Nez Percé tribe owns hunting, fishing, and mineral rights to the land.

Edna is a Nez Percé and Laguna Pueblo American Indian. Her mother, Frances, is Nez Percé, and her father, Ferris, is a Laguna Pueblo who grew up in New Mexico. Edna's parents met in Los Angeles, where many American Indians were relocated by the government for schooling and job training. Soon after they were married, her parents moved to Idaho, to the Nez Percé Reservation, where Edna was born in 1948. She was named after her father's sister, the wife of her maternal grandfather's nephew, and her maternal great grandfather's sister.

Rachel, Edna's grandmother, made moccasins and beaded coin purses from hides to sell. The earnings helped to support the Paisano family. Edna enjoyed helping her grandparents.

A mile down the road from the house were barns and a corral. Fifteen head of the Paisano's Hereford cows grazed on nearby land. The family raised the cows for beef. Their horses grazed near the barns. Two of the horses were gentle enough to ride. After their father came home from work, he walked with the children to the corral, so they could ride the horses and feed the cattle.

The Nez Percés are part of the Shahaptian language family. They were named Nez Percé by the French, who called them "pierced noses." The tribe is known for its beautiful Appaloosa horses, but by the time Edna was growing up, few Nez Percés owned Appaloosas.

Edna's father works for Potlatch Forest, Inc., a lumber company in Lewiston near the reservation. He loads plywood on boxcars for shipping. Her mother at one time worked at the local post office, and in the school cafeteria. But when Edna was in first grade, her mother started back to college and earned a teaching degree. Later, her mother received a masters degree in special education. In 1980, her mother went to Los Angeles to receive the Leo Reano Memorial Award from the National Education Association for leadership in education for American Indians and Alaska Natives.

Learning the Old Ways

Since both of her parents had jobs outside the home, in addition to house chores, animal care, and gardening, Edna spent a lot of time with her grandparents. They taught her how to find camas bulbs in the wet Weippe meadow. She learned how to bake them in a pit in the ground until the whitish bulbs turned dark, and could be eaten out of hand or stored throughout the winter. Camas bulbs had a sweet taste, and were a staple food for the family.

Daniel, Edna's grandfather, worked for the State Department of Highways. He helped build a road through the mountains. It was called Lolo Pass, part of the Lewis and Clark Highway. While Daniel spent four or five days out on the job making the roadbed, Edna and her grandmother went with him and pitched a tepee and tent several miles away on the Lochsa River. There they spent the day fishing, and sometimes they picked huckleberries. When her grandfather returned from work, they ate fresh food for their dinner.

Out in the mountains or back at home, her grandmother told stories and legends to the children before they went to sleep. From her grandparents, Edna learned a little of the Nez Percé language. "Wa-tu" means "no"; "ta'ts maywiy" means "good morning"; "Ne-mee-poo" means "the Nez Percé people."

Edna was very close to her grandparents. She confided in them her growing hopes for gaining knowledge about the wider world, and using this knowledge to help her people.

She says, "My grandparents always encouraged me to do whatever it was I wanted to do. When I was with them, I never had to worry about anything. I just felt so secure."

Edna was dear to her grandparents too. When she was grown up, her grandmother gave her a beaded dress with a design of thunderbolts and triangles.

At home, the family raised a vegetable garden. They planted corn, tomatoes, carrots, radishes and hot peppers. At haying time, she and her brother and sisters helped to haul hay. At branding time, they branded calves. For meat, they ate beef, elk, moose and venison.

Summer Pasture

The cattle were an important part of the family's livelihood. In the summer, when the temperature in the valley reached 100 degrees, the family took the cattle into the mountains about fifty miles away, where it was cooler and there was good grazing land.

Edna loved summer pasture where her family spent the weekends. The children rode the horses out along the fence line with their father, looking for breaks and helping with repairs. There were views of green meadows and pine trees and elegant red and white cows grazing in the distance. Cool breezes ruffled Edna's short black hair. She and her family slept in tents and cooked pancakes, eggs and meat over an open fire. At night they roasted marshmallows.

Being the Best She Could

Practically right away, when Edna started to school in the nearby town of Lapwai, she found out that learning came easily to her. In her school, half of the students were American Indian and half were white. Edna liked being good at her work, but soon she found out that others expected her to be very good all the time. She tried her best to live up to their expectations.

She loved sports and played softball and swam. When she was older, she became coach of a girls' league team in softball. She went to camp, and later became a lifeguard and counselor. Camp was held at state parks and offered swimming, horseback riding, craft and archery. Many of the American Indian children had no chance to play these sports the rest of the year.

At school, Edna's favorite subject was mathematics. She always did well in it. In high school, she took algebra, geometry and trigonometry, as well as chemistry and physics. In the math classes, she and her girlfriend had a lot of fun competing with the boys in their class.

"It was she and I against all the guys to see who could get the best grades," she recalls.

But the work was pretty boring for the bright student in the small country school. Only twenty-six students graduated in her class. Edna wished her mind could be stimulated more.

For her first two years of college Edna went to Boise College, which was off-reservation. She took two years of mathematics and again, she enjoyed it. It didn't occur to her to major in mathematics or science, however.

"Could I go back and say to the tribe, 'I am a mathematician'?" she asks.

No, she had to choose something that would be useful to her people. At that time, she didn't know how mathematics could be useful. The only choices were farming and teaching. Her education was paid for partly by her family and herself, but also by the Nez Percé tribe and by the Bureau of Indian Affairs, which is part of the United States government. By treaty, this Bureau was supposed to provide money to help educate young American Indians.

Edna wanted to return what was invested in her by working hard at a profession that helped her people. Jobs were few on the reservation. Many people worked at the lumber mill like her father. There were a very few jobs working for the tribal government. Later on, there was a health clinic on the reservation. But, at the time, there was no opportunity for Edna to use her mathematics or science, or to learn what she wanted to know.

Her life had taken a major shift. In order to follow the dreams she had confided to her parents and grandparents when she was a young girl, she knew she would have to leave the green valley and sparkling rivers and streams--the land she loved--and go outside the reservation.

About this time, Edna's older sister, who had graduated from college and gone off the reservation, took a job in Washington, D.C. She was a teacher for a VISTA project and worked with young Black students. After only a year there, she became ill and died.

The Paisano family felt a tremendous shock. Edna had spent weekends visiting her sister at college; she had looked up to her. She grieved for her sister.

Now, life off the reservation must have seemed terrifying to the young woman. But she remembered her parents', grandparents' and her older sister's confidence in her. A certain way of life was expected of her, and she intended to meet with courage whatever the future offered.

A Disabling Disease

One day, when Edna was only twenty years old, she woke up and found she couldn't walk. A disease had struck the active, sports-loving college student with no warning. It was rheumatoid arthritis.

"It was very hard," she recalls. "I used to play softball and swim almost every day, and now even walking is sometimes difficult."

When an attack comes, she has pain in her joints. Over time, the joints break down. When they do, they must be replaced. Five years ago, Edna had major surgery. Her hip joint was replaced with plastic and metal parts. After this, she was able to walk more easily.

Every day, she takes a drug, penicillamine, and sixteen aspirin. Over the past thirteen years, with her doctor's help, Edna has learned to control her disease. She has learned not to walk too far at one time, nor tire herself out. To keep her muscles toned, she swims and exercises.

Moving Off the Reservation

For her last two years of college, Edna transferred to the University of Washington in Seattle. She majored in sociology, graduated and went to graduate school there. Some jobs she held to pay her expenses were: Mt. Rainier park ranger; dormitory student advisor; and recruiter of American Indian high school students for the University. After two years, she earned a masters degree in social work.

Her years at the University were full and satisfying. In addition to her studies and part-time jobs, Edna and some other American Indian students developed contacts in the Seattle American Indian community. They lobbied to have Fort Lawton in Seattle turned into a community cultural center for the American Indians. When meetings and discussions did not persuade the federal government to give them this fort, which was legally theirs, Edna and sixty others held a sit-in at the fort. For this activity she was thrown into jail for a few hours. Eventually, this tactic worked. Fort Lawton has a thriving cultural center, Daybreak Star Arts Center, for the American Indians living in and around Seattle.

Upon graduating from college, Edna began working at a series of jobs that had some connection with her people and offered what she craves--knowledge about new fields. She was a social worker at the Public Health Hospital in Seattle in the rehabilitation ward. Many of her patients were from the reservations.

Moving to Washington, D.C., she worked as a program analyst in the Indian and Migrants Programs Division of the Office of Child Development. In this job, she visited tribal governments in the west and migrant camps in Texas and California. She made suggestions for giving money to these groups, and helped guide Head Start programs for children there.

She worked next for a private consulting firm, helping people in the tribal governments learn rules for good management. She learned how to produce films and slide shows about Indian affairs. She traveled and sharpened her skills in public speaking on reservations, and in Indian centers in cities. Of the six consultants in her firm doing this, she was the only woman.

Because of the arthritis, however, traveling was very tiring for the young woman. She decided to take a job in the government where she would stay in one place, the salary was good, and she had a chance to do something worthwhile.

Working at the Census Bureau

In 1976, no American Indian had ever been a full-time employee of the Census Bureau. Edna was the first.

"They had no one to give them our point of view," she says. "I was able to do something new. I was able to provide connections between the Census Bureau and tribal governments and other federal agencies."

At the present time, Edna is still the only full-time American Indian employee at central headquarters in Washington. In the Census Bureau regional offices, there is only one other woman and one man.

"I went to the Census Bureau because I was qualified," she says.

While Edna worked on her masters degree, she studied statistics. This laid the groundwork for the kind of work she does.

"It's important for persons who are American Indian and who understand American Indian affairs in this country to take these jobs.

"When I got to the Census Bureau, I realized how important it is for American Indians to know demography, computer programming and statistics: first, because there are very few American Indians in these fields; and second, because the government is always trying to assess things. With American Indian issues, it is very important to have people who can interpret the data accurately."

Every ten years, the U.S. Government Census Bureau counts the number of people and housing units in the United States and gathers information that helps government and private agencies plan for the future. This is important because the number of seats a state is allowed in the House of Representatives is determined by this census count.

Edna was hired by the Census Bureau to work on questions that concerned American Indians and Alaskan Natives. From 1976 to 1980, she and Karen Crook, a co-worker, constructed a special questionnaire that was given to American Indians, Eskimos, and Aleuts who live on reservations, along with the regular 1980 census form. [In Oklahoma, American Indians living in areas that used to be reservations were also given the special questionnaire.]

The Census Bureau held a "dress rehearsal," testing the special questions on American Indians. From the responses they received, they chose the best questions. They asked about housing, income, education, employment, and health. The answers would help tribal governments make better plans for the future. They would help the United States government live up to its treaty obligations more completely.

Edna says, "We will use the information from the 1980 census and special questionnaire as a starting point. We plan to estimate the population between now and 1990, when the next census is taken."

Of all the censuses taken so far, the 1980 census gives the most complete picture of American Indians and Alaska Natives. Edna's special questionnaire has helped to bring this about.

During the time of the 1980 census-taking, Edna visited several places to learn how the questions were being answered. American Indians in some locations complained that some of their people had not been counted. If this were true, later, when federal funds were given out to the tribal governments based on the census figures, these tribes would be given less. Edna helped to see that no one was missed.

Unlike the regular census form, the special questionnaires are not machine-readable; the computer can not pick up the information and they have to be coded by hand. Edna and Karen wrote all the coding instructions and developed code lists. Once this information is processed, Edna believes what she went to the Census Bureau to do will be completed. She feels satisfied that it is time to move on to new things, and she has plans for the future.

"I would really like to learn more about estimating, about applying formulas based on certain conditions, and about weighting data. I've done a lot of good in this job, but I need to study more statistics so I can continue to do things which are really important for my people."

Choices for the Future

Going back to school to take these courses is one choice she is considering. Another is to study law.

"Very few American Indians are lawyers and doctors, and there is a great need for them," she says.

But she would not go back to college simply to earn another degree. A doctoral degree is like marriage; it is not a goal she is seeking; however, if marriage occurs along the way, she would be happy.

Edna would only marry an American Indian. But she has not yet met one who suits her needs.

"Most men are threatened because I have a lot of knowledge and experience and I don't try to hide it," she says.

Neither have they understood her quest.

When Edna thinks about the future, and the exciting choices it holds for her, her black eyes sparkle. To learn more, and put her knowledge to use for her people, inspires this woman.

She may decide to live on the reservation where her father grew up--the Pueblo of Laguna in New Mexico. In the past few years, Edna has visited her relatives there. She has been given gifts of pottery during her visits. She has grown close to these relatives. She could study while she lives there.

"In the end," she says, "I'd like to live back on the reservation--like coming full circle. Going out, then coming back, to share all I've learned."

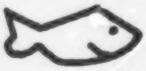
PATTERNS IN A STRIP

Both Edna Paisano and Fanya Montalvo are descendants of people who created beautifully designed pottery, jewelry and fabrics. Edna's ancestors are from two American Indian tribes; Fanya is from Mexico, a country of mixed Spanish and Indian influence. Both women vividly remember beautiful designs on favorite objects they grew up with. Edna speaks about the pattern on a Navajo bowl she was given in a special ceremony in New Mexico, and of the design on a wonderful dress her grandmother made for her. Fanya speaks of how fond she is of the designs of her people.

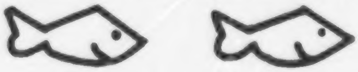
Perhaps these women were attracted by the mathematical rhythms of these patterns, as much as by their color and design. Patterns like these, that form a border around a bowl or dish, or a design on a bracelet or belt, are called strip patterns. Few people realize that such patterns are the result of different combinations of slides and flips. In fact, mathematicians who study mathematics of patterns have proven that all patterns on a strip result from only seven possible combinations of **slides** and **flips**.

What do we mean by a slide or a flip? Well, a **slide** describes a motion that is a lot like it sounds.

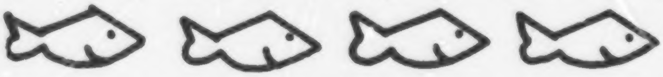
Draw a design; for example



Slide the design some distance and trace it. Now your pattern will look like this:

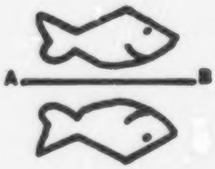


If you continue to slide and trace, your design will soon look like this:

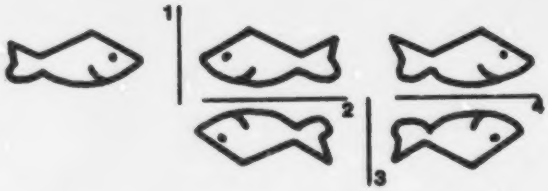


A **flip** describes a motion where you turn (reflect) your design before you trace it.

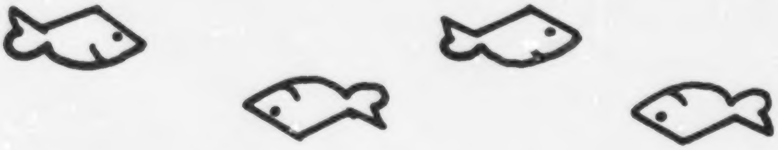
Pretend you were holding a mirror at AB. Depending on where the mirror is placed, the flipped figure will look different. For example, if we label the ends of the mirror A and B, mirrors placed in the following ways would flip the figure the ways you see here.



Some patterns are made by combinations of flips. For example, if you flip your original pattern thru line 1, then line 2, then line 3, then line 4, you will have a set of figures that look like this .



If you erased every other trace, your design would be well on the way to looking like this:



The pictures on page 143 are of bowls that were given to Edna Paisano by Navajo members of her family. Although the bowls are curved, they are decorated by strip patterns. Their designs suggest their names... **Bird** and **Lightning**.

Pretend the surface of the bowl is rubber, and that you have cut away the pattern and stretched and flattened it and fastened it to a strip of wood. Figure 02 shows the basic design unit and its flip transformation for **Bird**.

This is how the pattern is made. The top of Figure 02 is the design that all the rest is built from. Let's call it the **unit design**.

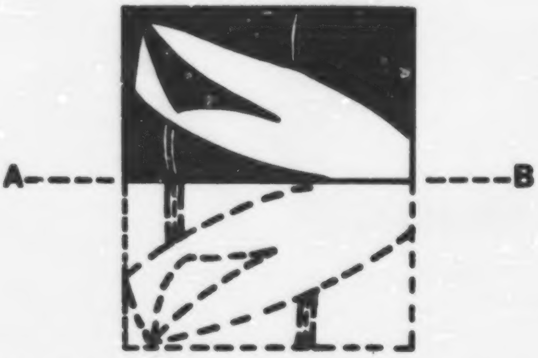


Fig. 02

1. Start by tracing the unit design in rectangle 1.
2. Flip the unit design through AB, and trace it in rectangle 2.
3. Slide and trace the design from rectangle 2 to rectangle 3.
4. Flip the design in rectangle 3 through AB, and trace the design that lands on rectangle 4.
5. Slide the design from rectangle 4 to rectangle 5.

Now you are back in the position equivalent to rectangle 1.

Continue step 2 ... flip and trace.
Then continue step 3 ... slide and trace.
Then continue step 4 ... flip and trace ... and so on.

When you have completed the rectangles in Figure 03, look again at the pattern on Bird. Do you recognize it now?

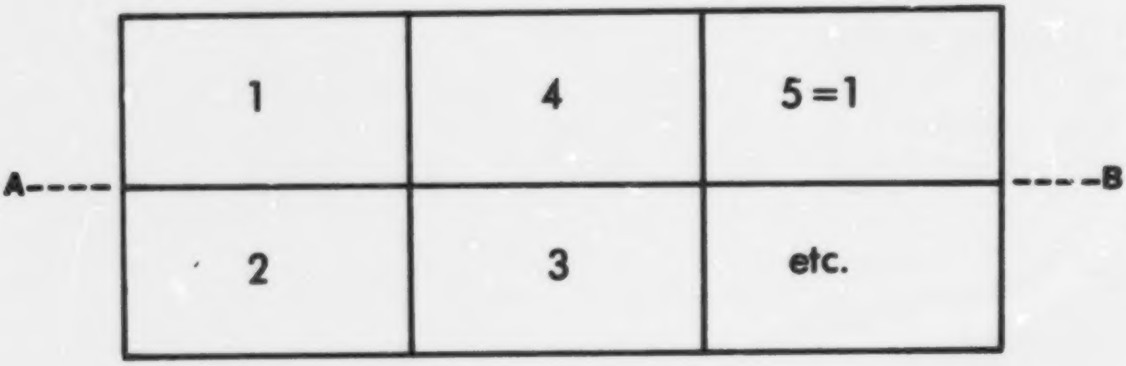


Fig.03

The unit designs on page 142 form the pattern on **Lightning**. Xerox the page. These are the design 'building blocks.'

Cut out the blocks on the xeroxed page.

Follow the transformation directions at the top of the page.

To make the strip design, paste the transformed units on a sheet of paper in the sequence in figure 04.

Continue the pattern.

If you like, copy more unit designs and extend the pattern.

When you are done, check that your strip pattern does indeed look like the pattern on **Lightning**.

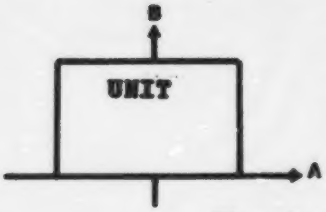
Now:

- Design your own unit pattern.
- Try different sets of flips and slides to create your own designs.
- Use your designs in weaving, wood carving, leather work, embroidery ... you name it!

1	4	5=1
2	3	etc.

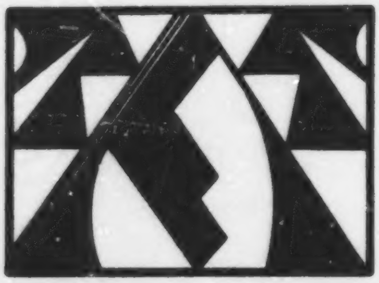
Fig.04

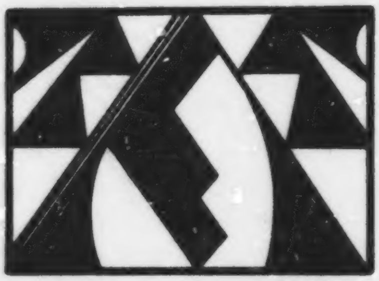
Reproduce the Strip Pattern with **unit pattern 'blocks'**. The **transformations. . .**

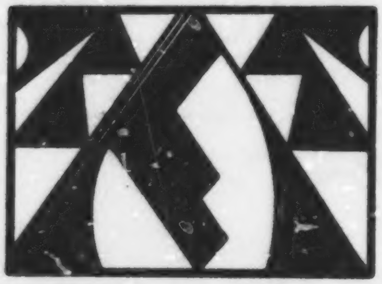


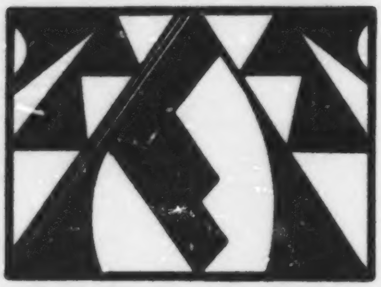
UNIT PATTERN	Place in rectangle 1
FLIP unit pattern through line A, then B	Place in rectangle 2
SLIDE unit pattern right	Place in rectangle 3
FLIP unit pattern through line B, then A	Place in rectangle 4
SLIDE unit pattern right	Place in rectangle 5

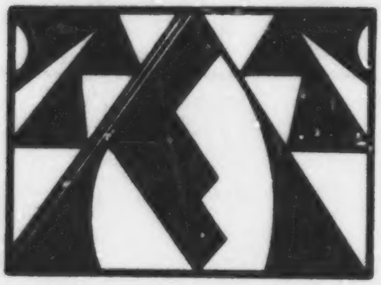
UNIT PATTERN

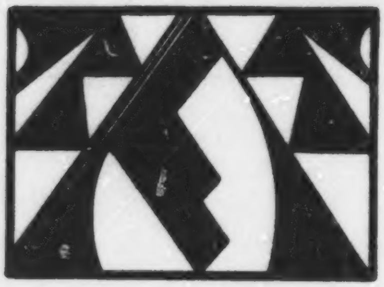












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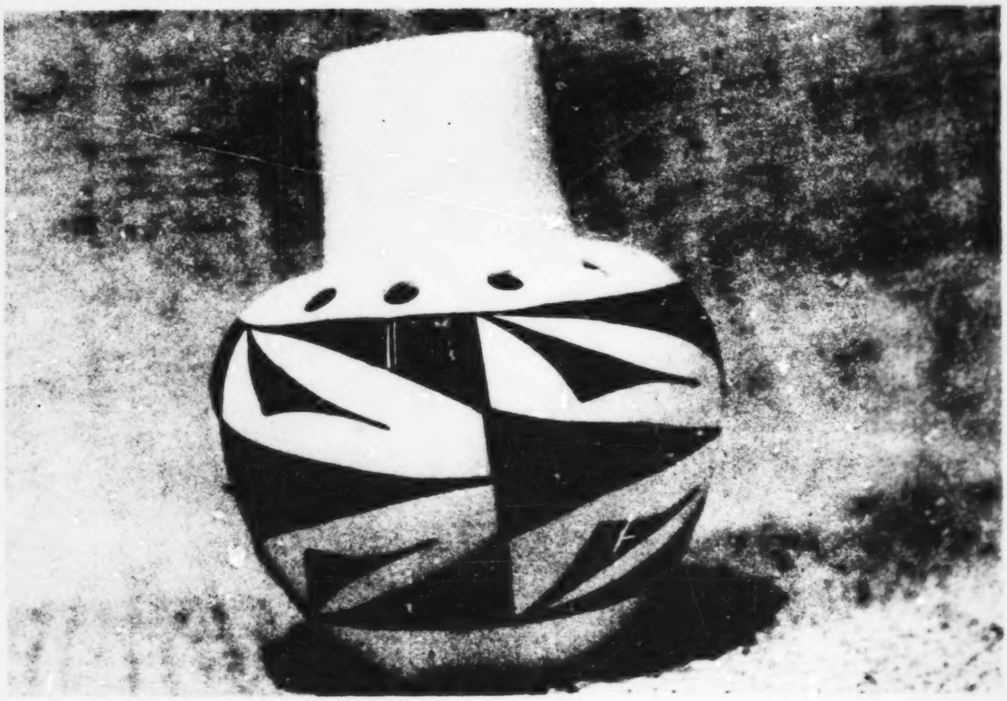
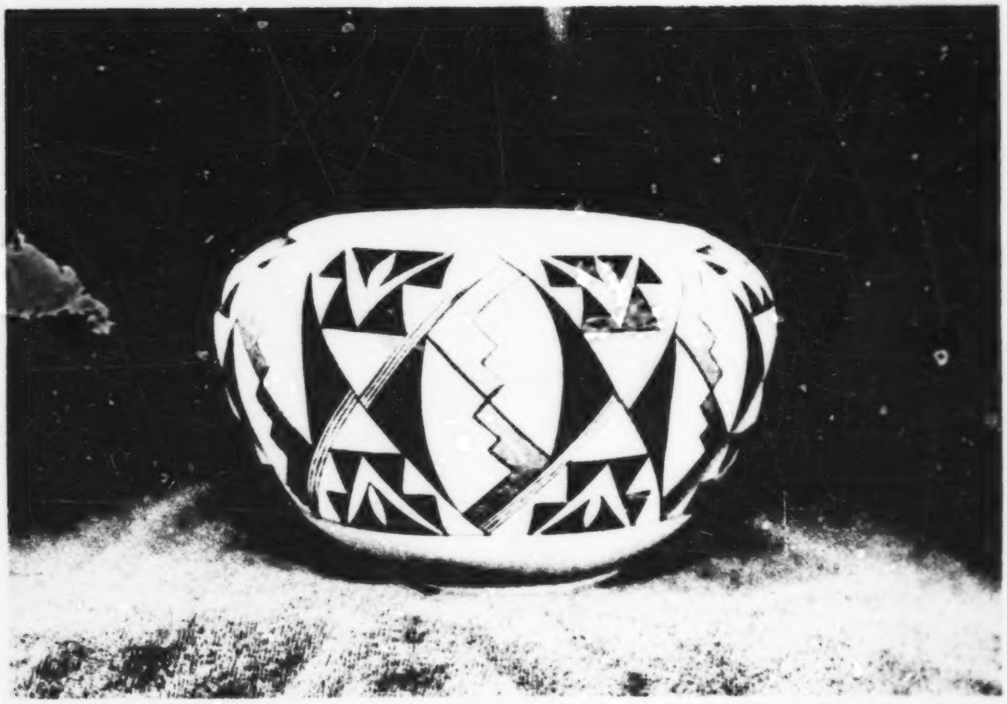


BIRD



LIGHTNING

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GRACE L. YANG

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GRACE L. YANG

1938-

Atop the City Wall

Grace bounced along in the small ricksha atop the city wall on her way to kindergarten. The ricksha had room for just two people, and the family servant wheeled the small girl along until they came to a big bump. The cart overturned, throwing little Grace to the ground. She jumped up, unhurt, and laughed. That was her first memory of her girlhood in Lanzhou, China.

From her birthplace in Guiyang to her present home in Maryland in the United States is a distance of over ten thousand miles. Not only are the miles great, but the way of life is vastly different. As Grace grew up, she made the change from one life to another step by step.

Grace's family has lived in Hunan province for several hundred years. However, for her first ten years, Grace lived the life of an "army brat"; that is, her family moved to quite a few different cities since her father, Chi Lo, was an officer in the Chin[illegible]ir Force.

Grace liked this kind of life. All the new places were interesting, [illegible]eir houses were spacious with beautiful gardens.

Grace is the second of three children. She has a brother who is eight years older and a sister seven years younger than she. Her father was very strict and not often at home. Grace was very close to her mother and remembers her with great affection. One time, her mother placed her on a blanket near some apple trees in the garden. The little girl heard ripe apples fall as a gentle breeze shook the trees. She would grab a large red apple, take one bite and throw it away; grab another and do the same, then another. What a picture she must have made with her shiny black hair and laughing brown eyes!

The Cornucopia of Life

Life itself seemed full of bounty, spilling out love and fruit, sunshine and cart rides, and many other pleasures. The birth of her younger sister, Wei Lan, when Grace was seven, changed her life only a little. Now Little Sister was the charmed one, and for this toddler Grace's mother even peeled grapes! Determined to have her share of this delectable treat, Grace would crawl up behind her mother, and as she dropped grapes to the baby, Grace intercepted them and popped them in her mouth. Only her giggles gave her away!

In the city of Hankow, where Grace lived from second until fourth grade, she attended a Christian missionary school. She remembers well the decorated trees and carols at Christmas time in school. Her own family practiced no religion, although they believed that the gods protected them.

From first grade on in China, students receive a rank within their group. Often, Grace held the highest rank.

"I got good grades," she remembers, "because I knew I would get into trouble if I didn't!"

From the third grade on, whenever Grace brought home good report, her mother gave her a beautiful ring. One time, when Grace got a high ranking, her mother left a pair of white leather shoes on Grace's bed as a surprise.

No More Time To Be a Child

In 1949, Grace was ten years old. That was the last year of her childhood. An automobile accident took her mother's life. Civil War between the Chinese Nationalist and Communist forces struck the country. Since Grace's father was a general in the Nationalist Chinese air force, it was necessary to move his family to an island off the southern coast of China. This was the island of Taiwan. Grace's grandparents went with them. The civil war went on.

Grace's father remarried. He and his new wife had six children altogether.

To her father, she and the other children were like enlisted soldiers and he gave orders to them. He was very strict and Grace had few outings and pleasures. In fact, life was very dull in the new household. She was permitted to go to the movies; in fact, she and her girlfriend competed to see who could see a movie the most times. Most often, she just stayed home and read novels in her bedroom. She read both Chinese literature and translations of foreign novels. All the romance she knew was through her novels. Dates with boys were not allowed in high school.

Number One Versus Number Five

With her mother gone, Grace began to realize some hard facts. She had to learn to take care of herself. Her grandparents helped and cared. Her grandfather kept track of how Grace did in school. Once when she brought back her report card, her grandfather asked, "Are you Number One?"

"No, Number Five," answered the young girl.

Her grandfather told her a story. "One of the emperors in the past took an examination. He came out Number Five. So, by decree of that emperor, Number Five *really* means Number One. *You* are Number One!"

Grace continued to do very well in school. Mathematics was her favorite subject. As the years passed, she mastered algebra, geometry, and trigonometry.

A Talk With Father

Her father believed everyone must go to college and earn a degree. College was part of their way of life. He believed, however, that education was important for its own sake, not necessarily as a path to a career. He especially wanted to shield Grace from the pressures of a career. For Grace, however, the possibility of a career was an important part of what education was all about. Therefore, when the form arrived in the mail, asking her to choose a field of study at the university, and Grace and her father sat down for their first discussion about Grace's future, their different views were all too clear.

"You will take literature," her father ordered.

"No, father, I don't like to write. I want to study chemistry."

"Not for a girl! History, then."

"Father, I would like to take a pre-med course!"

"To become a doctor? No, that is not for you. A career is too hard a life for you. Economics," her father offered.

"All right, economics," said Grace.

Four years later, Grace held a Bachelor of Arts degree in economics from the National Taiwan University. At the time, no residents of Taiwan were allowed to leave the island. College students were one of the exceptions. It was fashionable for parents who could afford it to send their sons and daughters to Japan or the United States to graduate school. To Grace, who had read foreign novels all through high school, foreign places and people were far more exciting than her real life. Margaret Mitchell's *Gone with the Wind* and Victor Hugo's *The Hunchback of Notre Dame* filled her with curiosity to see the world.

Thus, Grace decided upon the University of California at Berkeley for graduate school. She was twenty-two years old.

California was beautiful; she liked it right away. Here, everything--classes, friends, speech--was very casual. Grace began to evolve a far different way of life.

One of the changes was speaking the foreign language. She was uneasy and did not want to sound stupid when she spoke English. She was only willing to speak those words and phrases that she was sure were correct. As a result, some people thought she was completely fluent in English and rattled away at her until her head spun. Soon, however, she was speaking English with no trouble.

Studying Statistics in California

Grace had studied mathematics and statistics as part of her work in economics. She knew this was the area in which she wanted to continue. So she enrolled in the business school at Berkeley to work for a Masters Degree in statistics. After a week of classes, she realized she had made a mistake. Along with the statistics classes, she had to take business courses like marketing and accounting, which did not appeal to her. This she had not anticipated.

One afternoon, she was walking across the campus. She ran into her former mathematics professor from Taiwan, Professor M. J. Lu. He was also studying at Berkeley for the year. She discussed her problem with him.

"You must sign up for statistics in the Statistics Department!" the professor told her. "Here, come with me. I will show you the way."

Grace was admitted as a student. She had chosen the right place. This statistics department was rated among the top in the country.

Two years later, in 1963, Grace earned her Masters Degree in mathematical statistics. She continued her work for a Doctoral Degree. The next year, she married a man whom she knew from the National Taiwan University and met again in Berkeley whose name is Ta-Lun Yang. Ta-Lun was working on his Doctoral Degree in Mechanical Engineering.

All this time, Grace wrote to her father frequently and he to her.

"A career is not good for you," he wrote. "I don't want you to have a hard life. It is easier to stay home and read novels. If you continue this way, by the time you are forty you will regret it."

But Grace did not listen to this advice.

"No one ever forced a professional career on me," she says. "A sequence of decisions, each made at the time it was needed, led to my having a career. I can't remember seriously planning my future, say, further than four or five years."

Sticking With the Hard Work

As a doctoral student she worked under Professor Lucien Le Cam. For her doctoral dissertation, Grace wrote about stochastic epidemic models which describe the contagion of infectious diseases statistically.

"I knew Professor Le Cam was the right person to work with. He is one of the great men in statistics. I had to take a lot of additional mathematics to study under him. It was hard work," she recalls.

She stuck with it and in 1966 earned her Doctoral Degree. She and Ta-Lun, her husband, found they had a "two-body problem." [A two-body problem in differential equations deals with the equilibrium of two bodies. For the young couple, it meant finding a common place where they could both work!] They needed to find work in the same city. After some searching, they were offered jobs at Bell Communications in Washington, D.C. When the offer came in the mail, identical salaries were included ($15,000 x 2).

At first, Grace missed the beauty and the fine weather of California, but gradually she learned to like life in the suburb of busy Washington, D.C. That year, she sponsored her sister, Wei Lan, so that Wei Lan could move to this country from Taiwan. (Their father had died soon after Grace married.) Grace and Ta-Lun had two sons, Gwoping and Gwokang.

Grace is a full professor of statistics at the University of Maryland at College Park. A while ago, she stepped down as chairperson of the statistics program, a position she held for four years.

What a Career Really Means

Since she is now in her forties, Grace can look at the prophecy her father made to her so many years ago about women and careers.

"What he said is true in part, and he meant well," Grace says. "Life is a bit too busy. I never feel that I have two whole days together without thinking about the work. There is always something that needs to be done. Still, I do not regret my career. My work is important to me."

Few Women in Statistics

As a professor, Grace enjoys seeing good students come along and training them to become successful. Among these, very few are women, especially at the doctoral level. In her teaching experience, she has not noticed patterns of differences between performance by women or men. She believes that even if such patterns were seen, they should not be used to draw conclusions or to make predictions about the performance of any single individual. She has the impression, however, that women students at the graduate level, for one reason or another, appear to be more susceptible to leaving school than men.

"I remember several years ago we had a brilliant student," she says. "Unfortunately, she quit after finishing a master's degree and didn't go on for her doctorate."

Grace would like to see more women enter the mathematical sciences field. Out of eighty in the mathematics faculty at her university, only four are women. In her statistics branch, Grace is the only woman out of nine faculty members. For herself, she does not feel that she has been discriminated against as a woman in her work. But Grace is aware that sex discrimination exists, and that it can be discouraging to women trying to establish a professional career.

To prepare for a career in mathematical sciences, Grace feels, it is important that girls do well in pre-college mathematics.

"I have heard the comment in this country that mathematics is not a subject for girls," she says. "I didn't hear that kind of reasoning when I was in Taiwan. If young women don't continue taking math courses in high school, by the time they enter college their choice of fields will be very much restricted."

Methods, Models and Applications

Grace Yang's research interests include developing statistical methods and building stochastic models for special applications. Her university is located near the capital. Many government agencies are nearby. They do various types of statistical work.

Some of her research problems come out of the consulting work she does for government agencies. She finds the applied problems from these government agencies blend well, and, in fact, enhance, the theoretical research work she does at the university. She has worked on **spike-train** models. Spike-trains are neuron signals recorded by scientists with the help of specially designed instruments--micro electrodes and computers. Neurophysiologists like to discover the meaning of these signals and how they are transmitted and received by the brain. Statistical models are used to analyze these signals.

Grace is working on several other research problems as well. She finds her work challenging and stimulating. She feels fortunate to be involved in such interesting work.

Ants and Silkworms

When she was a girl in third grade, Grace already enjoyed conducting experiments. She built ant farms with bricks in her back yard. She liked the precision she observed in the ants.

Inside her house--in fact, in her own desk drawer--she raised silkworms. She liked to watch the life cycle of the worms and see the silk produced. First, to hatch the worms, she kept the eggs under a cushion until they hatched to black dots, like poppy seeds. Then she put them in the desk drawer to grow. There they were fed with mulberry leaves from the back yard. When the worms grew to about two inches, they gradually turned milky white. Each worm spun silk around itself, making a cocoon that looked like a peanut. To unwind the silk thread from the cocoon, the worm had first to be killed by dipping it in water. Not all were killed, however. Some were left in their cocoons to mature into moths which broke out of the cocoon and laid eggs. "The entire process was like magic," she remembers.

In the future, Grace plans to continue the work she is now doing. "There are plenty of things to do," she says. Whatever she does, she will always value the independence her work has brought her.

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WHAT IS STATISTICS?

Grace Yang works in a field called **statistics**. She is a **statistician**. Perhaps you do not know exactly what this means.

Statistics helps you make good guesses about answers to situations when you do not have (or cannot have) all the facts or **data** you need to get an exact answer. **Statistics** helps you get a pretty good answer from a **sample** of data.

This is an example. It uses a statistic called an **average**.

Suppose you want to know how many weeds are in your garden. The weeds are evenly scattered around. It would be tiresome, if not impossible, to count them all. Instead you count the weeds in several small areas around your garden. Each area is a **sample**. You add the weeds in each sample and get a total. You divide the total by the number of samples you used and get an **average**. This **average** is probably a better estimate of the number of weeds in an uncounted section of garden than a pure guess.

The next activity is a secret code. You can 'crack' this secret code by using statistics. To crack the secret code you need to know that certain letters of the alphabet appear very often. Some letters hardly appear at all.

Examine the following experiment. You might use these results, or repeat the experiment and use your own results.

Part 1: Get the Data

- Pick a passage from a book, magazine, newspaper or letter.
- Mark a passage that is exactly 100 letters long.
- Make a list of letters of the alphabet like the one here. Go through the passage and **make a mark** next to the letter on the list, each time you see that letter.

LETTER	MARK	TOTAL
a		
b		
c		
d		
e		
f		
g		
h		
i		
j		
k		
l		
m		

LETTER	MARK	TOTAL
n		
o		
p		
q		
r		
s		
t		
u		
v		
w		
x		
y		
z		

When you get to the 100th letter, total the number of times each letter appeared in that passage. Pick a different passage. Count, mark, and total the letters again.

Part 2: Get Some Samples

The more passages you count, the better your final result will be. It is a good idea to use different sources for different passages; for example, sometimes use books, sometimes magazines, sometimes newspapers. It is a good idea to combine results with others who are doing this experiment. If everyone in a class counts letters in a different passage and results are combined, the final sample will probably be larger and more accurate.

Part 3: Get an Average

Now you have several sample totals.

You need an average result.

In one experiment, using ten samples, A, B, and C appeared the following times in each sample:

SAMPLE #	1	2	3	4	5	6	7	8	9	10	TOTAL
A	12	13	11	10	10	4	4	7	11	10	87
B	1	2	1	0	1	0	2	1	4	3	15
C	4	2	5	1	1	2	0	3	3	3	24

To calculate an average number of times each letter appears, add the numbers from the separate samples. Then divide by the number of samples. In this experiment, there are 10 numbers from 10 samples. Getting a total for the numbers from each sample, then dividing the total by ten, the following averages were found:

LETTER	AVERAGE
A	87 10 = 8.7
B	15 10 = 1.5
C	24 10 = 2.4

For each letter of the alphabet, an average was found, then arranged in order, the letter having the highest average at the top, and the one having the lowest average at the bottom. If some letters were tied, any choice of order was made.

This is how it came out:

Averages Chart

Order	Letter	Average	Order	Letter	Frequency
1	E	12.5	14	U	2.4
2	T	9.6	15	M	2.3
3	A	8.7	16	G	2.2
4	O	8.3	17	W	2.1
5	N	6.6	18	P	1.6
6	S	6.4	19	B	1.5
7	H	5.6	20	Y	1.3
8	I	5.4	21	V	1.2
9	R	5.3	22	K	0.8
10	D	4.4	23	X	0.2
11	L	3.3	24	J	0.1
12	F	2.9	25	Z	0.1
13	C	2.4	26	Q	0.0

Compare your results with these. Do they look the same? They probably would not look exactly the same.

The Secret Message

Now that you know how often certain letters of the alphabet appear, you are ready to crack the secret code. Each letter is in disguise. Use your Averages Chart to establish each letter's true identity. When you substitute the true letter for the disguised letter, the message will appear.

Dec ika jkair re ma imta re sapesa rvob uabbija. Heviffi ifs Atoni vatgas lkora rva pesa ofbrais eq jeofj re rva Ibgaf ucbop rafr re uaar rvaok qirvak.

Count the number of times each letter appears. Order the letters by how frequently they appear. Compare with the letters in the Averages Chart above.

(Hint: The letter that appears most frequently is almost certainly E. The letter that appears next most frequently is almost certainly T; the next A, and the next. After that, you may have to do a bit of juggling to decode some of the other letters.)

(Further hint: As you decode the message, expect to find the name of at least one person and one place.)

Happy Hunting!

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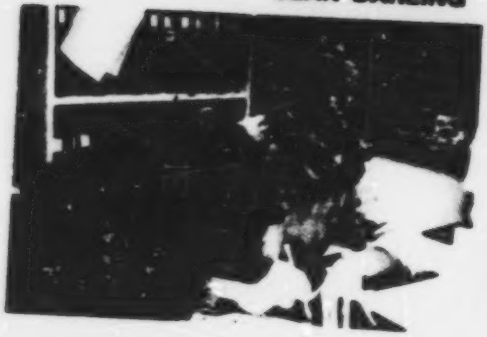
SALLY HANDY-ZARNSTORFF

KATHI DWELLE

JEAN DARLING



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THE WISCONSIN THREE

The Madison Academic Computing Center (MACC) sits toward the south side of a beautiful college campus, the University of Wisconsin at Madison. Seen from the tower rising behind it, MACC is a flat-roofed white building surrounded by trees. Just a five minute walk north, and the main landmark of the campus, Lake Mendota, is in sight. In winter, the campus is a landscape of bare trees and icy lake. In summer, there is lots of green grass and trees and shrubs--and sailboating on the lake.

The computer center shares a building with the computer science and statistics department. At MACC, some doors are open twenty-four hours a day. Computers sleep only when they "crash," or when they are shut down for maintenance. Otherwise, they are available for use around the clock. In fact, people, or users, are encouraged to use them at "off hours" when rates are cheaper and jobs run faster. This hustle and bustle goes on at the basement level. Here people work at computer terminals, cards that the computer reads are punched, and jobs are submitted to the computer. The public offices are on the main floor. On this floor, people can buy manuals and other printed materials that help them work with the facilities. Here, also, consultants answer questions and solve problems people run into when they use the computer. Consultants are available from 8:30 a.m. to 4:30 p.m. The schedule of consultants is set by MACC, and users talk to whoever is staffing the desk when they need help.

Among the twenty or so people whose job it is to answer questions are three computer programmers: Jean Darling, Sally Handy-Zarnstorff, and Kathi Dwelle. Each woman has taken a different path to reach this point in her career.

Here's what one person recalls about working with them:

I can remember when I was using the MACC facilities and needed consulting help. I would wait my turn in the queue or line until a consultant was available. When I saw that the *consultant was a woman, I felt disappointed. I thought that help from a man would be good; a woman, on the other hand, was not likely to know as much. If the help was not good, it was frustrating. Computer runs were expensive, and bad advance could waste time as well as money . . . and I was always in a rush for results.*

"Over the months, these feelings changed completely. After getting help from many different consultants, I found I was very happy to find Jean or Sally or Kathi at the consultant's desk when I needed help. If these women were there, I KNEW I would get my problems solved, or if they didn't know the answers, they would not waste my time and money by pretending they did. Instead, they would quickly get the problem solved by someone who did know. I discovered that women could do first-rate trouble shooting as computer consultants.

"I am embarrassed that my first attitude was sexist, but grateful to them for proving how wrong I was!"

JEAN DARLING

1949-

A High School Rebel

Jean Darling grew up in Madison in a family of four children. Her father was a professor in the History of Science Department; her mother was a housewife.

In the early 1960's, Jean was in elementary school, and she loved mathematics. She would work puzzles in the back of "Scientific American" in a column called "Mathematical Games." Games and puzzles were fun for her. Her father was proud of her and encouraged her. But when she became a teenager, his encouragement stopped. Perhaps he felt that science was not appropriate for a young woman, or that jobs would not be available to a woman scientist. Jean was confused at losing his support.

In high school she began to rebel. She felt that her time was wasted there. Her grades dropped and the situation at school was getting worse when an unusual opportunity came along. She had a chance to study in the north of France for her senior year. She seized this opportunity and left the country.

A year later, when she returned, the high school officials would not accept the French courses for credit and refused her a diploma, even though she had completed four years of high school work.

Refusing to let this stop her, Jean applied and was accepted at the University of Wisconsin at Madison and began her freshman year. She was uncertain about her future. She knew what she didn't want--she didn't want to be a housewife. Never! When she was twelve, she had made up her mind about that.

Trying a "Man's Field"

She wanted to earn wages as good as a man earned, and to do that, she thought, she should go into a "man's field." In 1969, a male friend of hers was earning $5.00 an hour as a computer programmer. This amount would be like $15.00 an hour now.

Jean says, "$5.00 an hour was a lot of money. This guy had long hair and a beard and was real scruffy-looking."

She thought, "He can work when he looks like this and still make a lot of money? This sounds like the life for me!"

About 1970, Jean moved from Madison to Phoenix, Arizona. There, she studied computer science at a technical college and earned a two-year Associate of Arts degree in computer programming. Now she was prepared for a field she liked and one that was well-paid. Very few women were in the field at that time, although now, women make up forty percent of the workforce in computer programming.

At first, work was hard to find, but eventually she landed a job at Messenger Corporation, a small printing firm in Phoenix.

While she was in school, in 1971, Jean married Bill Darling. Naturally, she continued her studies as a programmer. Four years later, in 1975, the Darlings moved back to Madison. There she worked for the State of Wisconsin and for Hopkins Agricultural Chemical Company. By this time, Jean had lots of experience as a programmer, so she became a consultant at MACC.

She says, "MACC is an unusual shop. It's an excellent place to work. It's not a monstrous organization; you have a lot of independence. People are treated well and they are open to hiring women."

At the present time, Jean is working as well as taking college courses. She expects to earn her bachelors degree in computer programming within a year. After that, she would like to go to Sweden and work for a time.

Community Computers: A Vision

Another goal is to use computers to help community organizations.

She says, "My vision is to have a community database where all the organizations in town make their names, addresses, and phone numbers available. Then a user would pay a quarter or whatever, sit down at a terminal, ask (for example) for all of the anti-nuclear organizations, and get a list of them to contact."

Jean and some other programmers are working toward this kind of community computer in Madison. Work such as this, which is useful to society, is important to Jean. And work helps her to be independent--a quality she prizes fiercely.

SALLY HANDY-ZARNSTORFF

1953-

"What Do You Want To Be When You Grow Up?"

Sally Handy and her brother, Bill, liked to fight and play together. They both were interested in sports and played them equally well. Therefore, when other people met them and asked Bill, "Are you going to be a doctor when you grow up?" but asked Sally, "Are you going to be a nurse?" the young girl had some strong feelings.

"I didn't want to be rude to this person and say, 'Well! you dumb idiot. I have no interest in being a nurse, and just because I'm a girl doesn't mean I can't be a doctor.' I never said that, but that's how I felt. It always bugged me that they thought women could only be nurses and men could be a doctor or anything they wanted," Sally says.

Everyone in her neighborhood played outside. They climbed an old shed roof and played fort in a nearby woods. Neighboring houses had large lawns and no fences separated property. When the children ran over the lawns, the owners didn't get angry. They said, "Oh, that's just Sally." The kids organized kickball, softball, and other street games.

At the beginning of junior high school, Sally moved from her small town of Wisconsin Rapids to Madison. She went to the same high school as Jean Darling, but she was a few years younger and the two didn't know each other.

A Short Course in Computers

In her junior year of high school, her math teacher, John Morley, introduced the class to short courses in computer programming. Sally signed up for these courses. The students had a terminal at school and learned to program in FORTRAN and BASIC. (BASIC is the math activity presented in a previous chapter.)

Sally was very good in mathematics and was immediately caught up in her teacher's enthusiasm for computers. Through these classes, she met her future husband, Mike Zarnstorff.

Two Loves: Math and Sports

Sally went away to Carroll College, a small, co-ed, liberal arts college. Out of several hundred in her class, only two women majored in mathematics. Often, in her advanced courses, there were no other women. This never bothered Sally. During one calculus course, two male students came up to her and asked her to tutor them, and Sally did.

Carroll College had women's sports and Sally joined the basketball, volleyball, and track and field teams. "Workouts were three hours a day, five days a week," she recalls.

There was no women's tennis team, but the coach asked her to join the men's tennis team. However, it conflicted with track and field.

KATHI DWELLE

1944-

Lighting a Spark

One hot summer day at the end of ninth grade, Kathi Dwelle stopped at school to pick up her final report card. Her algebra teacher called her into the classroom and showed her the results of a standardized mathematics test she had taken.

"Look at this!" he exclaimed. "You missed only three questions out of hundreds on this test. Let's sit down and figure out why you missed these three."

"He really lit a spark in my mind," she recalls.

Kathi lived in a very small town in southwestern Minnesota called Walnut Grove, which is the setting of the television show, "Little House on the Prairie."

In her graduating class, there were only 57 students. Kathi was valedictorian of her class. Her highest grades were in mathematics. She took algebra, geometry, solid geometry, trigonometry and advanced algebra. Her older brother (who now has a doctorate degree in agronomy) used to ask her to help him with some of his tougher math homework problems. By senior year, she was the only girl in the advanced mathematics class. This didn't bother her a bit; in fact, she liked it.

Kathi's mother was a housewife and her father was a farmer. The nearest university was over one hundred miles away. Her mother had married when she was nineteen and wasn't financially able to go to college, but she was determined Kathi would get a chance to develop her talents.

Pursuing the Study of Mathematics

Kathi went to Hamline University in St. Paul and majored in mathematics, graduating in 1966. There were no computer sciences departments in universities then, but she thought computer science was an exciting, well-paying field.

She took a battery of tests at IBM and was hired as a junior programmer.

She says, "Industry probably has changed, but in the late sixties at IBM, there was absolutely no freedom. You were very closely watched. There were buzzers to tell you to begin work, have lunch, and quit work. If you arrived after 8:00 in the morning, security guards took down your name and reported you."

"There were dress codes at that time. Males had to wear suits or sports coats and a white or blue shirt. Females were strictly forbidden to wear slacks."

Kathi still remembers the day when her manager asked him to help decide if cullotte skirts were acceptable. She voted yes and they were allowed. She also created a sensation when she was the first to wear a mini-skirt to work!

Two years later, Kathi married Dick Dwelle. Life at IBM was not what she had hoped, so she had no regrets when they moved to Madison so that Dick could study for a doctoral degree in English literature.

In Madison, Kathi went to work at MACC as a programming consultant. The young couple liked Madison and Kathi liked her job.

Computer Science--A Good Job

For twelve years, she has worked at MACC, first as a consultant, then in the graphics department, where she learned to design special plots and three-dimensional plotting programs.

Kathi liked graphics design, but after a time she had learned all she could in that department. She moved into a newly created department as coordinator of Contract Programming. (Contract programming means doing programming for users who need a special expertise in their work. These users make a contract with a programmer to do this work for some agreed-upon fee.) Kathi supervises two contract programmers and five consultants.

Meanwhile, her husband left the field of English Literature. If he became a professor of English, he reasoned, he would probably be hired in a small town, where there would be no computer work for Kathi. So he joined a firm in Madison as a stockbroker and found that he likes the work.

At times, Kathi works fifty to sixty hours a week. She thinks the best part of her work is her contact with people.

"I work with dozens of highly educated, intelligent people who work in interesting fields. When they come to me to help them design programs, I think, 'What can I do to solve this?' I really like solving problems. I'm always curious to see what the results of their research will be once they have been analyzed by the computer."

Kathi uses primarily FORTRAN and sometimes COBOL languages because most of the clients she works with are analyzing scientific or research data (although some have business applications) and these languages are most used in these fields.

She says, "With computers you have to be flexible in your work hours because the computer isn't always working. You arrange your schedule around other things too. Computer time at night is cheaper. If I know a client doesn't have much money, I may come in at night and run jobs at the cheaper night-time rate."

Supporting Other Women

When she first took over the Contract Programming position, she began to deal with clients who were always in a hurry. She worked so hard and felt such strain, her stomach hurt and her hair began to fall out! But soon, she learned to say "No" and "You'll just have to wait!" She persuaded her manager to hire more staff to work with her, and gradually she has learned to handle the job pressures.

When Kathi first arrived at MACC in 1968, lots of women were on the staff. Many were earning money to support the family while their husbands were in graduate school. Then, in the early seventies, there was a purge. Half of the staff was laid off. MACC was told it had to "tighten its belt" and balance the budget.

Kathi kept her job but she realized that, by 1976, only three other professional women were working in a staff of fifty people! She and another woman went to the Affirmative Action Officer at the University and reported this fact. They also discussed it with the Director of MACC. As new jobs opened up, the Computing Center began to hire more women and now, once again, lots of women work on the staff.

MACC no longer hires people without experience and trains them. Only people with programming experience or degrees in computer science are hired today.

"In the early days," Kathi explains, "computer time was very expensive and people were inexpensive to hire and train. Now just the opposite is true--computer time has come way down in price, but salaries are much higher and so are training costs."

Sharing Equally is Best

Kathi and her husband, Dick, have decided they do not want to have children. The two of them share the housework--such as cooking, laundering, and vacuuming--equally.

They eat breakfast together, which Dick prepares, and dinner, which Kathi prepares. Both of them like to cook.

In Madison, the Dwelles have good friends. Kathi says, "In a university community, you find that your friends are always finishing school and leaving. But now that my husband has a business here, we have friends who are also in business and are staying around."

With Kathi's many interests, she has found that all she really needs is more time. Eventually, she would like to work three or four days a week and have time to devote to the many activities she enjoys, such as gardening, gourmet cooking, canoeing, biking, skiing and travelling.

MACHINE LANGUAGE

Computers really only understand a language called **machine language**. All other computer languages like **BASIC** or **FORTRAN** or **ADA**, which is a new language (see page 31), must be translated into machine language.

All machine language words are made up of 8 bits of information. These bits are either 0's or 1's. They are represented, in the machine, as tiny switches that are either on (1) or off (0). Each 8-bit word is called a **byte**. We can feed decimal numbers into the computer which will then translate them into machine language bytes of 0's and 1's.

The following activity is a puzzle that uses this idea.

- Start with a sequence of decimal numbers like 12 or 23 or 57.
- Translate these decimal numbers into base 2.
- Then write the base 2 number as a pattern of zero's and one's in a row.
- Shade all regions where a ONE (1) appears.
- Leave all regions where a zero (0) appears blank.

Translate Decimal Numbers into Binary (Base 2) Numbers

To change any decimal number to a binary (base 2) number, write the number as the sum of powers of 2. (Powers of 2 are 1, 2, 4, 8, 16, 32, 64, 128 . . . Notice each number in this sequence is twice the number before it.) The table on page 169. compares binary numbers with decimal numbers.

- Notice: 12=1(eight)+1(four)+0(two)+0(one)
  This is written as $12=1100_2$
- Notice: 23=1(sixteen)+0(eight)+1(four)+1(two)+1(one)
  This is written as $23=10111_2$
- Notice: 29=1(16)+1(8)+1(4)+0(2)+1(1)
  This is written as $29=11101_2$

Writing Numbers in the Decimal System			Writing Numbers in the Binary System					
10^2	10^1	10^0	2^5	2^4	2^3	2^2	2^1	2^0
100's	10's	1's	32's	16's	8's	4's	2's	1's
		1						1
		2					1	0
		3					1	1
		4				1	0	0
		5				1	0	1
		6				1	1	0
		7				1	1	1
		8			1	0	0	0
		9			1	0	0	1
	1	0			1	0	1	0
	1	1			1	0	1	1
	1	2			1	1	0	0
	1	3			1	1	0	1
	1	4			1	1	1	0
	1	5			1	1	1	1
	1	6		1	0	0	0	0
	1	7		1	0	0	0	1
	1	8		1	0	0	1	0
	1	9		1	0	0	1	1
	2	0		1	0	1	0	0
	2	1		1	0	1	0	1
	2	2		1	0	1	1	0
	2	3		1	0	1	1	1
	2	4		1	1	0	0	0
	2	5		1	1	0	0	1
	2	6		1	1	0	1	0
	2	7		1	1	0	1	1
	2	8		1	1	1	0	0
	2	9		1	1	1	0	1
	3	0		1	1	1	1	0
	3	1		1	1	1	1	1
	3	2	1	0	0	0	0	0

In the following example, 62, 34, 2, 14, 14, 2, 34, and 62 are written as sums of powers of 2 (Figure 05).

Fig.05

62 = 32 + 16 + 8 + 4 + 2
34 = 32 + 2
2 = 2
14 = 8 + 4 + 2
14 = 8 + 4 + 2
2 = 2
34 = 32 + 2
62 = 32 + 16 + 8 + 4 + 2

In Figure 06, a one (1) is placed in each column where that power of 2 is needed to represent the number; zero's (0) are placed where that power of 2 is not needed.

For example:
62=1(32)+1(16)+1(8)+1(4)+1(2)+0(1)
Therefore we write 62=111110_2

Another example:
34=1(32)+0(16)+0(8)+0(4)+1(2)+0(1)
Therefore we write 34=100010_2
This is done for all 8 numbers to complete the grid.

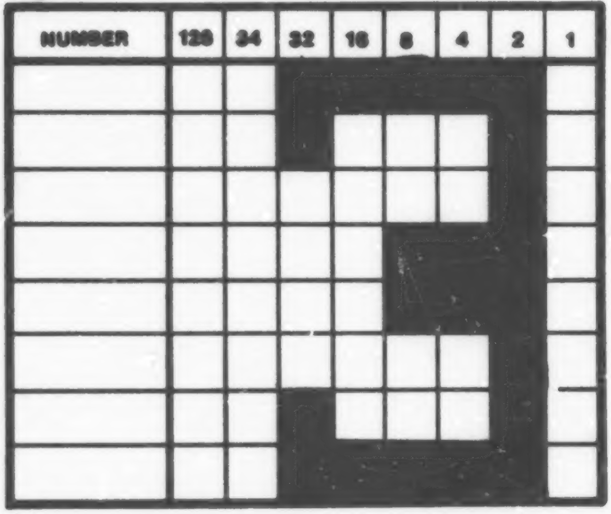
Fig.06

NUMBER	128	64	32	16	8	4	2	1
62			1	1	1	1	1	0
34			1	0	0	0	1	0
2							1	0
14					1	1	1	0
14					1	1	1	0
2							1	0
34			1	0	0	0	1	0
62			1	1	1	1	1	0

Then all squares that have a one (1) inside are shaded. All those that have zeros (0) are unshaded.

Figure 07 shows the completed picture.

Fig.07



Discover the pictures 'hiding' in the grids below.

Remember: 1. Translate each number into its binary form.

2. Record the 1's and 0's in the appropriate columns.

3. Color all squares that have 1's inside.

28=16+8+4, therefore 28=11100_2

NUMBER	128	64	32	16	8	4	2	1
28				1	1	1	0	0
20								
28								
9								
126								
72								
20								
34								

NUMBER	128	64	32	16	8	4	2	1
149								
149								
149								
245								
149								
149								
148								
149								

NUMBER	128	64	32	16	8	4	2	1
56								
108								
56								
145								
210								
86								
52								
24								

NUMBER	128	64	32	16	8	4	2	1
126								
255								
219								
24								
60								

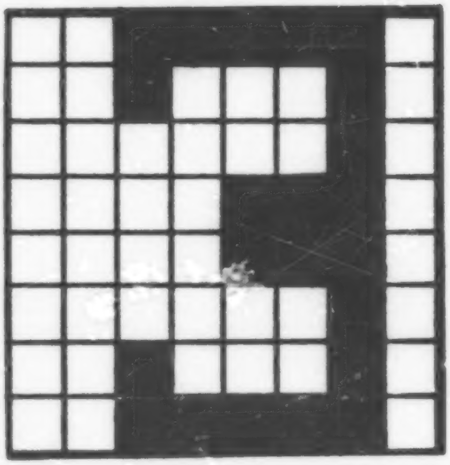
NUMBER	128	64	32	16	8	4	2	1
27								
60								
126								
255								
66								
90								
90								
126								

NUMBER	128	64	32	16	8	4	2	1
48								
56								
60								
62								
63								
160								
255								

NUMBER	128	64	32	16	8	4	2	1
24								
140								
70								
255								
70								
140								
24								

Make up your own puzzle pictures for a friend.

1. Make a picture by coloring regions black or white.
2. In a blank grid, write a '1' in any square that is black. Write a '0' in any square that is not.
3. Translate these base 2 (binary) numbers into decimal numbers.
4. Give the numbers to a friend. Can your friend reconstruct your picture?



		1	1	1	1	1	0
		1	0	0		1	0
						1	0
				1	1	1	0
				1	1	1	0
						1	0
		1				1	0
		1	1	1	1	1	0

NUMBER	128	64	32	16	8	4	2	1

NUMBER	128	64	32	16	8	4	2	1

In COLUMNS B write the binary equivalent for each decimal number in COLUMN A. (See page 168 to learn how to change decimal numbers into binary numbers.)

In COLUMN C write S if the binary number is symmetric. Write N if the binary number is not symmetric.

A pattern is symmetric if it can be folded in the middle such that one half covers the other half exactly.

Since binary numbers are numbers made up of a pattern of 0's and 1's, we can look at these patterns and decide whether they are symmetric or not.

Using this definition, 3 would be symmetric, since 3 is 111_2 in binary notation, and 1⋮1 is symmetric on both sides of the dotted line.

Similarly, 7 is symmetric since $7 = 111_2$ and 1⋮1_2 is the same on both sides of the dotted line.

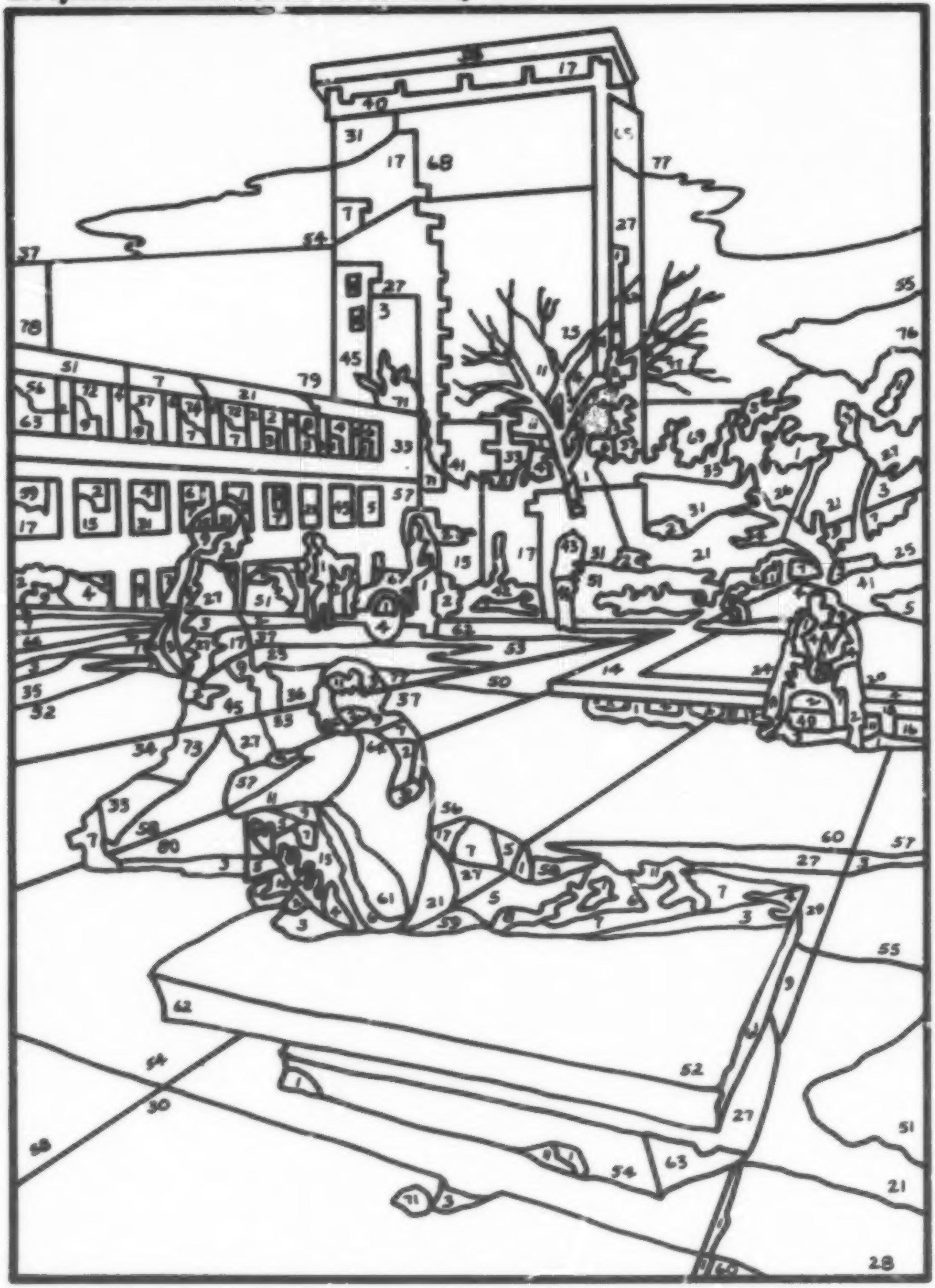
On the other hand, 4 is NOT symmetric since $4 = 100_2$ and 100_2 is NOT the same on both sides of any vertical dotted line you could possibly draw.

Decimal Numbers to Binary Numbers – Some Symmetric, Some Not

Continue the following list:

A	B							C
	64	32	16	8	4	2	1	S=SYMMETRIC N=NON-SYMMETRIC
1							1	S
2						1	0	N
3						1	1	S
4					1	0	0	N
5					1	0	1	S
6					1	1	0	N
7					1	1	1	S
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
•								
•								
•								

The University of Wisconsin -- Shade all regions containing decimal numbers that are symmetric when translated into binary form.


33
17
40
65
31
17
68
77
7
54
37
27
3
27
55
78
23
76
45
51
7
79
21
56
37
71
11
63
9
33
69
35
41
33
1
27
39
57
31
26
21
3
17
15
31
5
15
17
43
51
25
21
41
4
27
51
4
5
61
3
17
37
53
23
14
35
50
24
36
37
32
45
53
49
16
34
73
27
57
33
56
7
59
80
60
57
3
15
7
5
27
3
51
11
7
3
29
61
21
59
3
55
9
62
54
52
30
27
51
63
68
54
21
71
3
60
28

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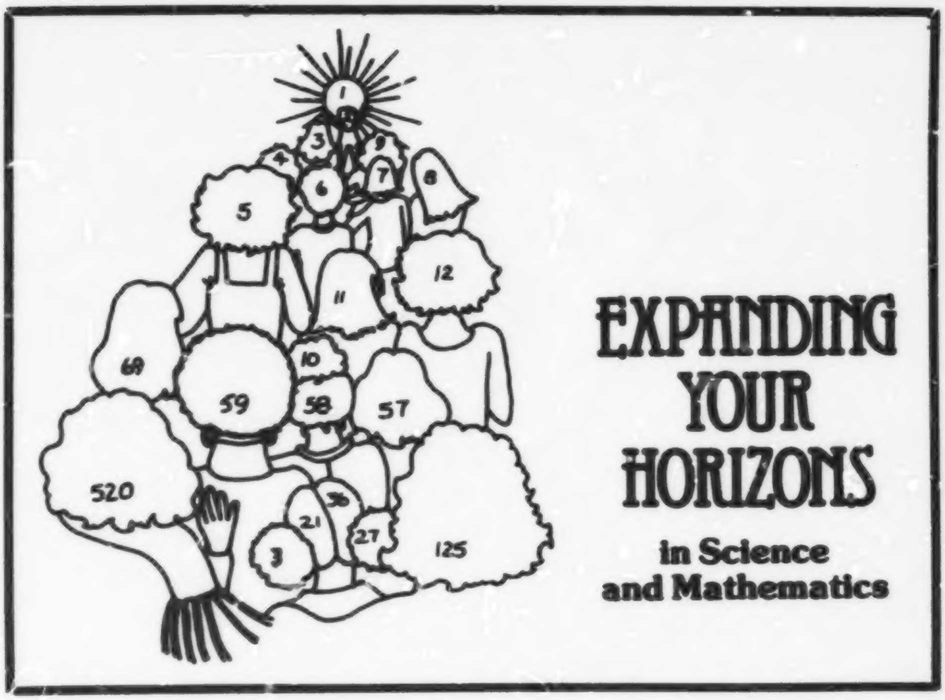
This picture is from an Expanding Your Horizons conference brochure.


1
3
9
4
6
7
8
5
12
11
69
10
59
58
57
520
36
21
27
3
125
EXPANDING
YOUR
HORIZONS
in Science
and Mathematics

When 4 is divided by 3 the remainder is 1. The same is true for 1, 7 and 10.

When 5 is divided by 3 the remainder is 2.

What is the remainder when 8 is divided by 3? ______

when 11 is divided by 3? ______

when 12 is divided by 3? ______

To color the picture from the Conference brochure, divide each number by 3 and find the remainder.

If the remainder is 0, color the hair red.

If the remainder is 1, color the hair yellow.

If the remainder is 2, color the hair brown.

So 4 is colored yellow. What is 5 colored?

Expanding Your Horizons

by Joanne Pugh

I glance at the brochure next to me on the car seat. "Expanding Your Horizons in Science and Math . . . A Conference for Seventh to Twelfth Grade Women . . . March 21st . . . Mills College." As I begin looking for the Mills exit along the freeway, scenes from my high school years drift before my eyes. In those days, Miss Farnum, my elderly, grey-haired geometry teacher, was the only female I knew interested in mathematics. My mother hated math and was defiantly proud of repeating Algebra I four times before finally passing. I made a prompt if graceful exit from the bleak landscape of angles and triangles immediately following Miss Farnum's class in tenth grade. The message was forever etched on my mind: women and math don't mix.

Turning onto the campus, I pass Mills Concert Hall. It's only 8:15, but a long line of girls has already formed outside on the wet walkway. As the line moves slowly forward into the Hall, more girls keep coming--alone, in groups, with parents, wearing jeans, kilts, sweatshirts, silk blouses, quilted jackets and slickers. A large bus pulls up near the packed sidewalk. Thirty more girls, all dark-eyed, with black hair, and speaking Spanish spill out onto the street guided by a lone man wearing green sunglasses.

I skirt the crowd and edge toward the door of the Hall. A short, round woman, curlers covered by a vivid orange scarf, shepherds two girls inside and pushes them toward a table marked M-P. I am reminded of early morning crowds waiting to buy tickets to hear their favorite rock group. Today, however, it is science and math, not pop music, which has drawn these young women from their beds so early on a weekend morning. They are only five hundred of the eight thousand girls gathering at that moment on college campuses around California ready to spend the day solving math problems, running computers, and learning about careers in science and engineering.

Inside the Hall, I see Nancy Kreinberg of the conference planning committee. As Director of Math and Science Education for Women at the Lawrence Hall of Science, and Co-Director of the Math/Science Network, she has been working on programs for women and math for seven years. I approach her and ask about the history of the conferences.

"This all began in 1976," she says, motioning to the crowd, "when we held our first conference here at Mills. Two hundred girls attended, and it was very successful. Since then, the demand has been so great that today there are seventeen conferences in California alone. We've spread into ten other states and even overseas Our newest addition is Australia."

The conference, Kreinberg continues, is sponsored by the Math/Science Network, a group of nine hundred scientists, educators, and community people. They organize events like Expanding Your Horizons to help girls understand why math is important, and to show them that women can be successful in technical fields.

It is 9:30, and the conference is about to begin. For the next hour, there will be a panel discussion on careers for women in science and engineering. The Concert Hall is totally filled, so I sit in the aisle, ready to hear the four women seated on the stage. Two engineers, a veterinarian, and a physical therapist will discuss their jobs, their lives as women in science, their education, and career preparation.

Zella Jackson is tall, slender, and pretty. She is also Manager of Manufacturing Systems at IBM in San Jose and responsible for two hundred million dollars' worth of software products. Somehow, she doesn't fit my concept of a "woman" engineer.

"My algebra instructor probably changed my life," she tells the girls. "She had faith in me and believed I could do it. My father also influenced me by favoring my brothers. I was competing for his attention, so I did things like take shop. When I graduated from Michigan State University in 1974, I was the only woman and the only Black to receive an engineering degree. I love my work. I am challenged and well paid. I also have a viable career with many options."

Jackson's message was one that would be repeated throughout the day: "At your age, don't drop out of anything. Keep your options open and check them all out."

For a moment, Zella Jackson fades away and my mother reappears. I am fourteen years old and telling her that I want to study biology or medicine. She replies, "But you'll have to take calculus and physics, and you won't be able to do it. It's just too hard. Drop out now while your math grades are still good."

Zella Jackson is finished speaking and Dee Jacobson, the veterinarian, has taken the stage. "I recently ran a twenty-six mile marathon," she begins, "and I look at my career in the same way as I regard this race. When I decided to try for the marathon, everyone said, 'You can't do that. You'll die.' I started training and worked at it every day. When the race began, I didn't know what to expect. After twenty miles, I found out--my body ran out of fuel, my legs hurt, I got cramps, but I didn't stop. I decided to be a vet when I was ten. People discouraged me, but I didn't listen. Like the race, I just kept going, and here I am."

By now it is 10:30, and the girls are leaving the Hall to attend math and science workshops. The rest of the morning will be spent in the lab or classroom participating in hands-on problem-solving sessions led by local women scientists, mathematicians, and tradespeople. I take a moment and glance at the material that Nancy Kreinberg has given me.

In elementary school, girls show as much interest and ability in math as boys. But around seventh or eighth grade, these same girls drop math when it is no longer a required subject. During the important junior high school years, female students typically begin avoiding math in favor of English, history, home economics, or "general" courses. Well-meaning teachers and counselors often guide girls away from math and science into courses they view as both more suitable and more useful. These choices, made at age fourteen or fifteen, can have a negative effect on a girl's ability to earn a good living later in life. As our society depends more on computers and technical machines, students without enough mathematics preparation will be left out of many good jobs.

Putting the articles and fact sheets in my notebook, I start out in search of the workshops. The sun is shining now, and the morning has become warm and humid. Wendy Beyea, an operations engineer, leads a group of girls onto the lawn in front of Mills Hall. She is about to begin a surveying exercise, and the girls are carefully following her instructions, adjusting a rod, changing an angle, kneeling, measuring, moving, kneeling, measuring again. Nearby, plumber Naomi Friedman has gathered another group around the back of her truck. Her hands are strong and confident as she carefully sands a piece of copper pipe.

"You need to make sure the pipe is very clean," she is saying, "so the solder will stick." Twelve pairs of eyes follow her motions, as twelve pairs of hands slowly start sanding.

I move into Lucie Stern Hall where classroom doors are open to accommodate the change in temperature. Groups of girls everywhere are solving problems, discovering patterns, predicting answers.

"O.K. girls, check your facts," calls out Dot Mack, an Oakland math teacher working in Room 35. "Good! That was fun: I liked the way you handled the problems."

From another room comes the clicking of dice, as the girls roll and roll again for a probability exercise. Workshop leader Virginia Thompson, mathematics instructor with the Professional Development Program at UC, Berkeley, urges them on.

"What numbers appear most often?" she asks, and the reply, "Sevens and elevens," comes quickly.

Leaving the problem solvers, I join the analyzers over in the Chemistry, Physics, and Mathematics Building. Jacquey Barbar from the Lawrence Hall of Science is supervising an experiment in Room 107. "Tell me," she asks, "What happened when you put those chemicals in the flame?" A young Black woman with thick braids wreathed around her head speaks up in an authoritative voice. As she finishes, Barbar beams, "Good! You're right! You worked really well. I seldom get such a clean set of data and I am very impressed. I wish you all luck." The girls gather their papers and start to leave. It is time for lunch.

As I walk toward Mills Tea Shop, I think about the events of the morning. Never had I seen so many women scientists and engineers gathered in one place nor had I experienced such enthusiasm among young women for technical subjects. When I was young, there were always a few girls, perhaps two or three in a class, who liked math. But I had never seen five hundred together, all so excited about science and math. The effect was very powerful. Today, at the conference, these young women are no longer unusual, different, or painfully obvious. Their interests are confirmed, their career hopes supported, their enthusiasm encouraged.

Comments one ninth grader, "There are only two girls in my advanced-placement math class, and I sometimes feel like an outcast. Now I see other people have done it, and I can, too." I react briefly to her words, feeling some regret about my own past experience, and then pick up my bag lunch from the tables outside the teashop.

Inside, I join a group of people already enjoying roast beef and avocado sandwiches. The conference program includes seminars to inform parents and teachers about a variety of issues important to their children's education. While students are solving math problems and completing experiments, adults meet with representatives of local colleges, attend workshops on career development, and learn strategies to keep their daughters enrolled in math.

I turn to the woman on my left and discover that our children go to the same junior high school. She explains how the morning workshops helped her understand why girls dislike math. We compare notes and find our backgrounds are similar. The difference lies in the gender of our children. Mine, a son, is planning on science as a career. Hers, a daughter, wants to be a writer and is already eager to drop math.

It is nearly 1:00, and the girls are wandering back to the classrooms ready to attend the afternoon career workshops. During the next two hours, students will meet in small groups and form personal contacts with role models--women pursuing careers in science, engineering, and the trades. I glance at the twelve sessions offered and am surprised by the variety of fields. Microbiologist, sanitation engineer, landscape architect, immunologist, biostatistician, medical economist and medical physicist, cytologist, and CPA are just a few of the thirty-six careers represented. This afternoon, together with the young participants, I will learn what a cytologist does, how one becomes a biostatistician, and what courses are necessary to prepare for any scientific field of work. How I wish I had had a similar opportunity back in the ninth grade.

The career sessions are now in progress. I notice that, in addition to requesting specific job information, the girls are concerned about three major issues: family, discrimination, and money. The conflict between family and career is a very real one. The girls don't believe that science and the usual "feminine" interests can be mixed. Questions such as "Do you know about anything else, like art or music?" and "Can you still have children?" indicate the girls' concern about choosing a "masculine" career. I can almost hear a sigh of relief when Diane McEntyre, head of the Mills Math Department, describes how she majored in math, worked for IBM, had her first child, and then pursued studies for a Ph.D. in computer science. McEntyre also notes that "it helps to have a supportive husband."

The girls are also concerned about being the only woman among all male workers on a job.

"When the men start bothering you," one tenth grader asks, "how do you turn them off?"

Laughter greets this question and also the response, when electrician Diane Kutchins replies, "It's like when the boys tease you in school. You just ignore them."

The consensus among the role models is that although women earn less and advance more slowly than men, a truly competent person eventually succeeds. Perhaps the most surprising to me, who had always thought self-fulfillment the primary reward of work, is the persistent "How much money do you earn?" These young women are concerned about the economic realities of their future, as well as with fulfilling their personal interests. The salaries quoted are impressive: $20,000, $27,000, $35,000--and seem enough to encourage even the most math-shy student not to drop out.

It is three o'clock, and the conference is over. As I head back to my car, I am surrounded by a group of girls leaving Lucie Stern Hall. Their excited conversation is easy to overhear.

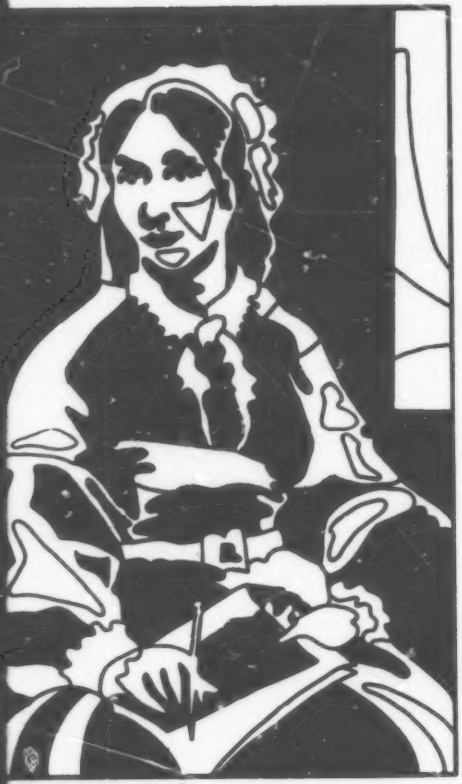
"I want a career in space sciences," one says to another, "and now I know that taking physics is important."

Her companion nods and replies, "This conference lets you get guts and go for what you want. I'm going to be a doctor, and am definitely looking forward to my career. I know I can do it."

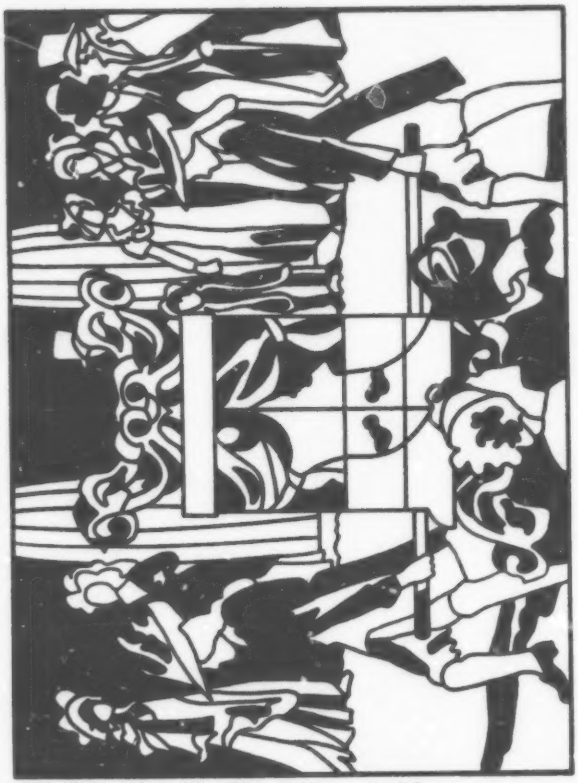
Who, When and Where

	Dates	Place of Birth
Mary Somerville	1780-1872	Scotland
Ada Lovelace	1815-1852	England
Sonya Kovalevskaya	1850-1891	Russia
Mary Everett Boole	1832-1916	England
Emmy Noether	1882-1935	Germany
Lenore Blum	1943-	United States
Evelyn Boyd Granville	1924-	United States
Fanya S. Montalvo	1947-	Mexico
Edna Lee Paisano	1948-	United States
Grace L. Yang	1938-	China
The Wisconsin Three		
Jean Darling	1949-	United States
Sally Handy-Zarnstorff	1953-	United States
Kathi Dwelle	1944-	United States

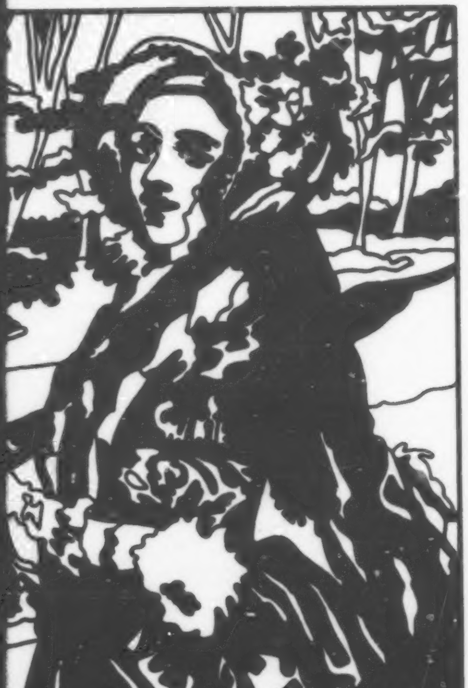
SOLUTIONS TO ACTIVITIES



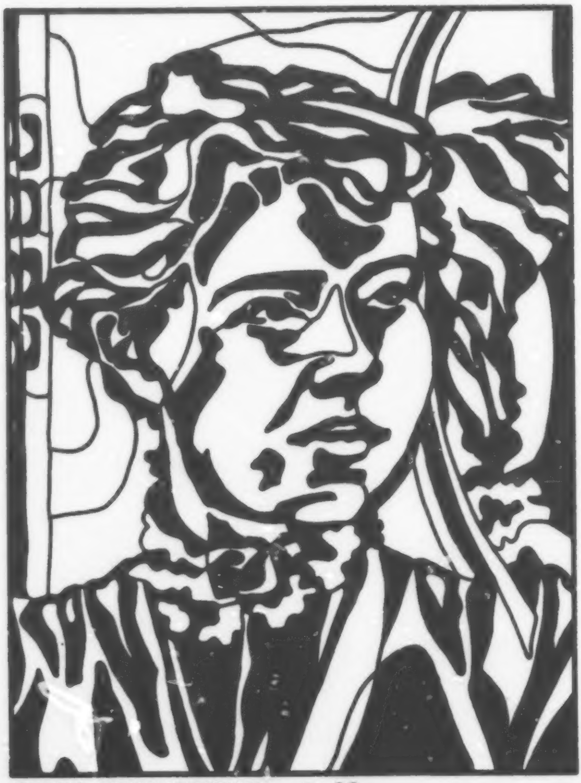
MERVILLE P.8



ON THE WAY TO THE BALL P.19



ELACE P.20



SONYA KOVALEVSKAYA P.38

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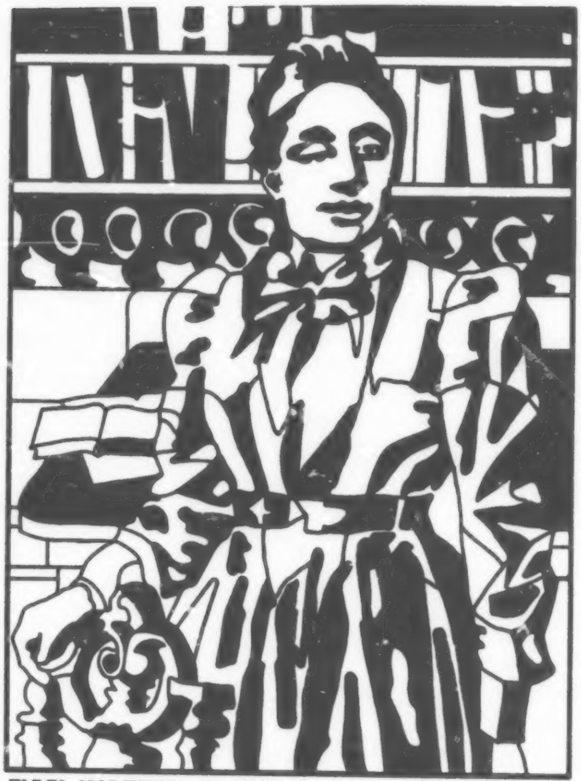
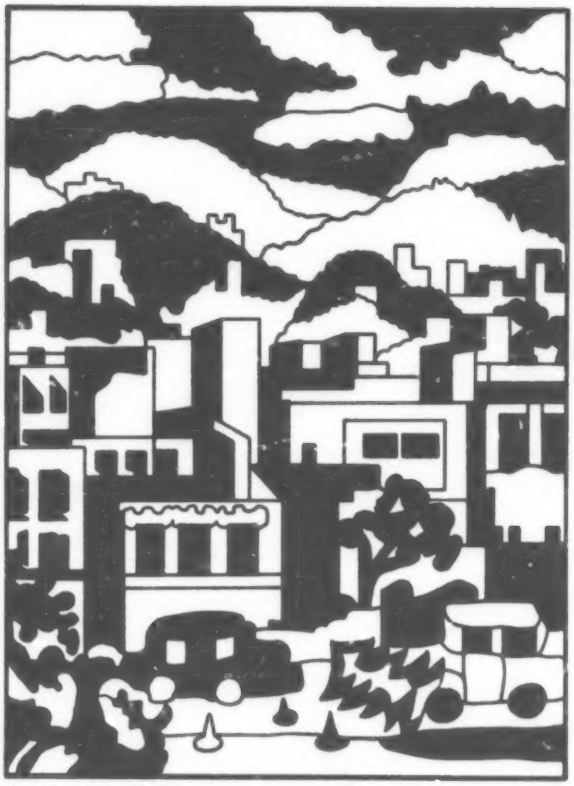
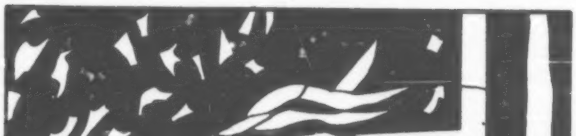


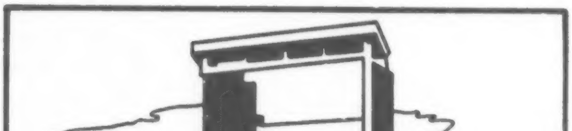
EMMY NOETHER P.66



CARACAS P.96



FAYNA'S PET TRURL P.126



UNIVERSITY OF WISCONSIN P.178

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Triangular Numbers from 1 to 210

1, 3, 6, 10, 15, 21, 28, 36, 45, 55, 66, 78, 91, 105, 120, 136, 153, 171, 190, 210

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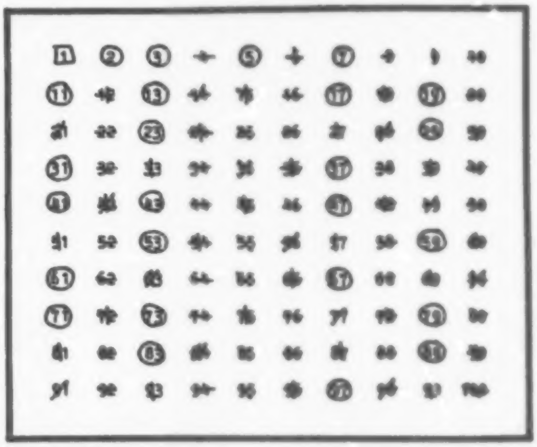

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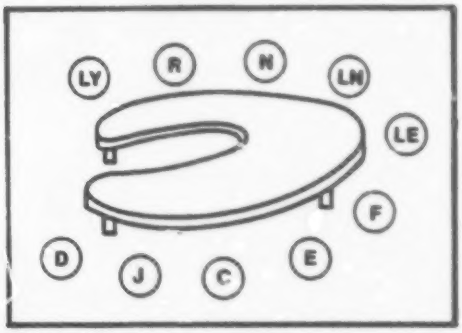
LY
R
N
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F
E
C
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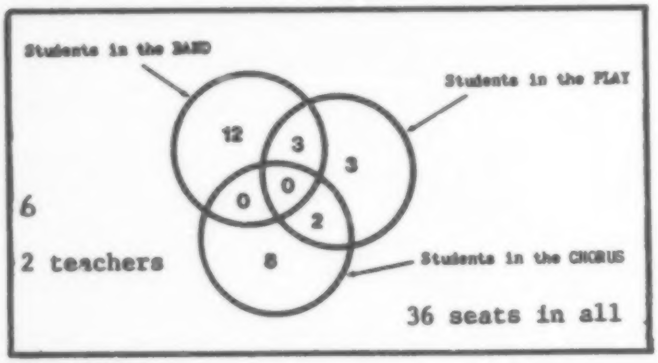
D

page 94


Students in the BAND
Students in the PLAY
Students in the CHORUS
12
3
3
0
0
2
8

6

2 teachers

36 seats in all

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Fibonacci Numbers from 1 to 1000

1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144, 233, 377, 610, 987

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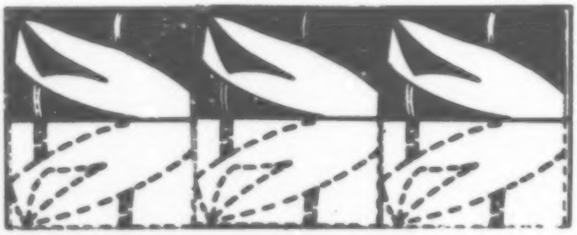

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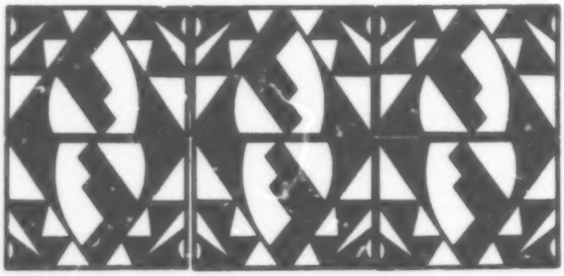

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You are great to be able to decode this message. Johanna and Eliza helped write the code instead of going to the Aspen music tent to meet their father.

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Symmetric Binary Numbers between 1 and 80

Decimal	Binary
1	1
3	11
5	101
7	111
9	1001
15	1111
17	10001
21	10101
27	11011
31	11111
33	100001
45	101101
51	110011
63	111111
65	1000001
73	1001001

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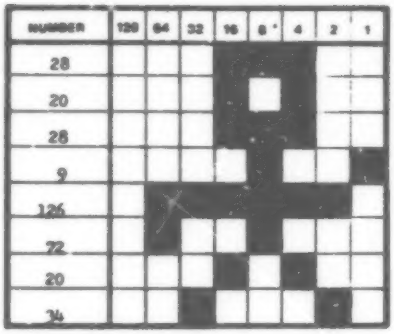
NUMBER	128	64	32	16	8	4	2	1
28				1	1	1	0	0
20				1	0	1	0	0
28				1	1	1	0	0
9					1	0	0	1
126		1	1	1	1	1	1	0
72		1	0	0	1	0	0	0
20				1	0	1	0	0
34			1	0	0	0	1	0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1
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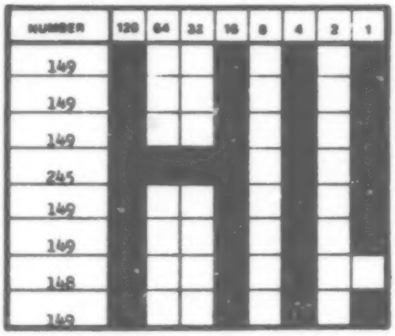
28
9
126
72
20
34

page 171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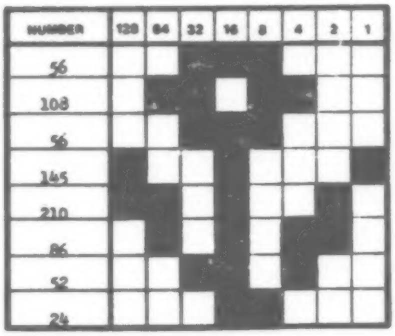
64
32
16
8
4
2
1
149
149
149
245
149
149
148
149

NUMBER	128	64	32	16	8	4	2	1
149	1	0	0	1	0	1	0	1
149	1	0	0	1	0	1	0	1
149	1	0	0	1	0	1	0	1
245	1	1	1	1	0	1	0	1
149	1	0	0	1	0	1	0	1
149	1	0	0	1	0	1	0	1
148	1	0	0	1	0	1	0	0
149	1	0	0	1	0	1	0	1

page 171

NUMBER	128	64	32	16	8	4	2	1
56			1	1	1	0	0	0
108		1	1	0	1	1	0	0
56			1	1	1	0	0	0
145	1	0	0	1	0	0	0	1
210	1	1	0	1	0	0	1	0
86		1	0	1	0	1	1	0
52			1	1	0	1	0	0
24				1	1	0	0	0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108
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145
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86
52
24

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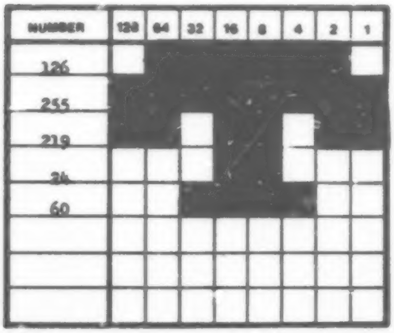
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16
8
4
2
1
126
255
219
24
60

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255	1	1	1	1	1	1	1	1
219	1	1	0	1	1	0	1	1
24				1	1	0	0	0
60			1	1	1	1	0	0

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NUMBER	128	64	32	16	8	4	2	1
27				■	■		■	■
60			■	■	■	■		
126		■	■	■	■	■	■	
255	■	■	■	■	■	■	■	■
66		■					■	
90		■		■	■		■	
90		■		■	■		■	
126		■	■	■	■	■	■	

NUMBER	128	64	32	16	8	4	2	1
27				1	1	0	1	1
60			1	1	1	1	0	0
126		1	1	1	1	1	1	0
255	1	1	1	1	1	1	1	1
66		1	0	0	0	0	1	0
90		1	0	1	1	0	1	0
90		1	0	1	1	0	1	0
126		1	1	1	1	1	1	0

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NUMBER	128	64	32	16	8	4	2	1
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56			1	1	1	0	0	0
60			1	1	1	1	0	0
62			1	1	1	1	1	0
63			1	1	1	1	1	1
63			1	1	1	1	1	1
160	1	0	1	0	0	0	0	0
255	1	1	1	1	1	1	1	1

NUMBER	128	64	32	16	8	4	2	1
48			■	■				
56			■	■	■			
60			■	■	■	■		
62			■	■	■	■	■	
63			■	■	■	■	■	■
63			■	■	■	■	■	■
160	■		■					
255	■	■	■	■	■	■	■	■

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NUMBER	128	64	32	16	8	4	2	1
24				■	■			
140	■				■	■		
70		■				■	■	
255	■	■	■	■	■	■	■	■
70		■				■	■	
140	■				■	■		
24				■	■			

NUMBER	128	64	32	16	8	4	2	1
24				1	1	0	0	0
140	1	0	0	0	1	1	0	0
70		1	0	0	0	1	1	0
255	1	1	1	1	1	1	1	1
70		1	0	0	0	1	1	0
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24				1	1	0	0	0

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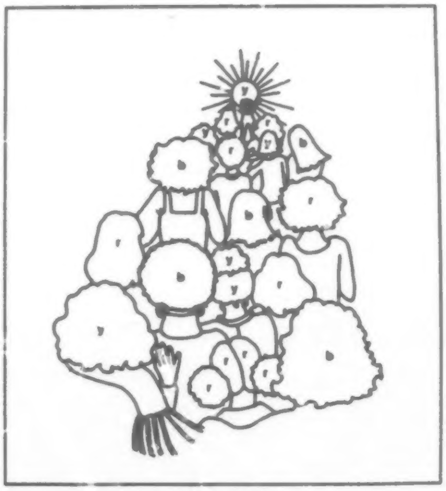

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